Teachers Teaching with Technology™
Professional Development from Texas Instruments

Exploring Common Core Topics in Statistics with TI-Nspire™ Technology

Materials for Workshop Participant*

There are three categories of T³ Professional Development, each with a unique set of learning objectives. This workshop is focused on content knowledge, and its objectives are as follows:

Content Knowledge

- Emphasis on content with technology as support
- Addresses critical, tough-to-teach topics and new content standards for CCSS or TEKS
  - I have a deeper understanding of the mathematics and science in my content area, and I am aware of the shifts in content that affect what I teach.
  - I can design opportunities for students to use technology as a tool to deepen their understanding of mathematics and science.
  - I can locate and download TI activities that align to my standards.
  - I can describe the role technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in the practice and content standards.

Workshops focused on instructional practices and technology integration have the following objectives:

Instructional Practices

- Emphasis on classroom practices with technology as a tool to enhance student learning
- Models CCSS, TEKS, and NGSS tasks using in-depth discussions, reflective practices, and essential technology skills
  - I can demonstrate the importance of teacher actions for students' engagement in the Practices, and I can take actions that will enable students to become mathematical and scientific practitioners.
  - I can describe the role that technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in practice and content standards.
  - I can design tasks for students to employ the Practices, using technology as a tool to deepen their understanding of mathematics and science.
  - I can ask questions designed to make student thinking visible – to push them to think about connections, make comparisons, or probe their understanding.

Technology Integration

- Emphasis on learning to use TI technology, with broad "how-to" coverage highlighting a wide range of features
- Subject/content-focused training on appropriate usage of TI technology in the classroom
  - I am comfortable with essential technology skills for exploring math and science content.
  - I can design opportunities for students to use technology as a tool to deepen their understanding of mathematics and science.
  - I can locate and download TI activities that align to my standards.
  - I can describe the role technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in the practice and content standards.

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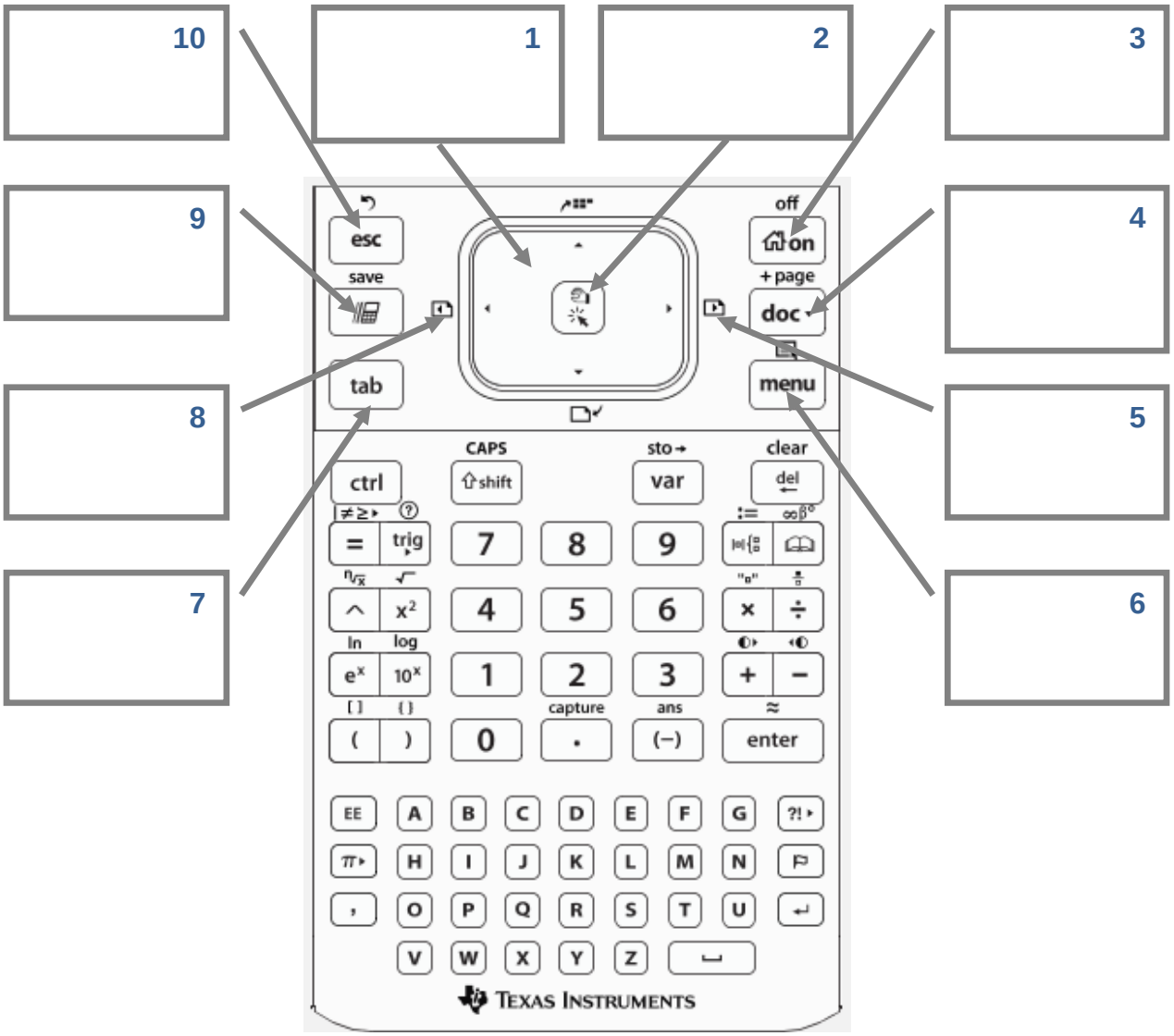
TI-Nspire™ CX Family Overview

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity you will become familiar with the most commonly used keys on the TI-Nspire™ CX family of handhelds.



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TI-Nspire™ CX Family Overview

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will become familiar with the layout of the TI-Nspire™ CX family of handhelds.

Step 1:

Locate the Touchpad. The Touchpad is used to navigate the cursor around the screen. What appears in the center of the Touchpad?

Step 2:

Locate the keys to the left of the Touchpad. How do some of these keys compare in name and location to keys on a computer keyboard?

Step 3:

Note the light blue or yellow color of the commands that appear above many of the keys. Which key do you push to access the light blue or yellow options on the key pad?

Step 4:

Many of the traditional shortcut keys used with computer software are available on a TI-Nspire handheld. For example, ctrl C and ctrl V are used to "copy" and "paste," respectively.

Step 5:

Note the colors of various keys and the location of the alpha keys. What do you notice about the arrangement of the keys?

Step 6:

Where are the buttons for adding, subtracting, multiplying, and dividing located?

Step 7:

Press on to turn on the handheld. If the Home Screen is not displayed, press on again. Use the tab key to move to each of the Home Screen options. Note the applications available on the bottom row of the Home Screen.

Step 8:

Note the Scratchpad options available on the left hand side of the screen and the icon in front of the Scratchpad. Locate the Scratchpad key on the handheld.

Step 9:

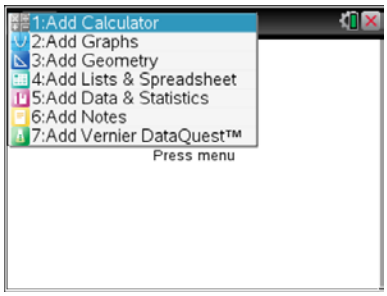
Select **Settings > Status** from the Home Screen. You will find the available memory and the battery status noted on the screen. Press esc or press ⚙ to choose OK to exit the Status screen.

Step 10:

Select **Settings > Document Settings**. Explore the options available. Press esc or, using the Touchpad, move to OK and press ⚙ to exit the Document Settings menu.

Step 11:

From the Home Screen, select **New Document** to start a new document. If prompted to save the current document, select No. Choose **Add Calculator**. This Calculator page is the first page of the first problem in this new document. The tab indicating problem one, page 1 (1.1) is displayed in the top left corner of the screen.



Step 12:

Using the Touchpad, move the cursor to the icon to the left of the red **X** in the top right hand corner of the screen. What information is provided?

Interpreting Linear Models

Student Activity

Name _____

Class _____

Open the TI-Nspire™ document *Interpreting_Linear_Models.tns*.

In this activity, you will create a scatter plot of mean pulse rates before and after exercise and explore the relationship between the two variables.

Jackie's class has been studying health and nutrition. One of the students read an article about pulse rates before and after-exercise. The students wondered whether you could predict their after-exercise pulse rates from their before-exercise pulse rates. The class measured their pulse rates before and after exercise for five days. The data in the "before" columns represent the mean pulse rate for the five days at the beginning of class for a student. The entry in the corresponding "after" column represents the mean pulse rate of that student after one minute of doing jumping jacks.

Note: All of the students in Jackie's class are aged 16 or 17.

	Pulse Beats/Min **before-exercise**	Pulse Beats/Min **after-exercise**			Pulse Beats/Min **before-exercise**	Pulse Beats/Min **after-exercise**
1	86	164		16	73	144
2	88	164		17	73	136
3	75	140		18	79	145
4	88	160		19	79	141
5	64	137		20	86	150
6	84	136		21	98	156
7	85	154		22	74	136
8	93	140		23	76	122
9	93	164		24	96	160
10	86	156		25	92	145
11	87	153		26	58	140
12	96	154		27	84	148
13	72	145		28	92	150
14	67	134		29	88	141
15	62	129		30	80	130

Move to page 1.2.

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

The data from the table have been entered into a Lists & Spreadsheet page.

Interpreting Linear Models
Student Activity

Name _____

Class _____

Move to page 1.3.

Page 1.3 is a Data & Statistics page. To graph the scatter plot, move the cursor to the "Click to add variable" message near the lower center of the screen. Press [·] to display the variables. Select the independent variable.

Move the cursor to the middle of the left side of the screen. When the "Click or Enter to add variable" message appears, press [·] to display the variables. Select the dependent variable.

Select **Menu > Analyze > Add Movable Line**. Transform the movable line until it fits the trend in the data well.

- To rotate the line, move the cursor to the graph of the line near the edge of the graph screen. When the rotation symbol (↻) appears, press [ctrl] [·] to grab the line. Use the Touchpad to rotate the graph. When finished, press [·] or [esc].
- To translate the line, move the cursor to the graph of the line in the center of the screen. When the translation symbol (✣) appears, press [ctrl] [·] to grab the line. Use the Touchpad to translate the graph. When finished, press [·] or [esc].

1. a. What is the equation of your movable line?

   b. Interpret the slope of your line in terms of the mean pulse rates.

   c. Is the *y*-intercept of your line meaningful? Why or why not?

   d. Give the coordinates of a data point that is very close to the line. What after-exercise pulse rate does your line predict for the person whose data point you identified? How far off is this prediction?

   e. Give the coordinates of a data point that is not very close to the line. What after-exercise pulse rate does your line predict for the person whose data point you identified? How far off is this prediction?

2. Select **Menu > Analyze > Residuals > Show Residual Squares**.
   a. What does the length of the side of each square represent?

   b. What does the area of each residual square represent?

   c. Record the value of the sum of squares for your movable line.

   d. Move your movable line to several different locations. What do you observe about the residual squares and the sum of squares of the residuals?

   e. Change your movable line until the sum of the squares of the residuals is approximately 9,000. Then change the movable line until the sum of the squares is approximately 2,500. What do you observe about the relationship between the sum of the squares of the residuals and the fit of the movable line?

   f. Change your movable line until you have the smallest value that you can determine for the sum of the squares of the residuals. What is that sum of squares?

3. Select **Menu > Analyze > Residuals > Hide Residual Squares**. Move your movable line so that it has the same equation as your answer to Question 1a. Then select **Menu > Analyze > Residuals > Show Residual Plot.**

   a. In the top work area, move the cursor over the point you identified in Question 1e as a point that is not very close to the line. What do the coordinates of the point represent?

   b. Click on this point, and observe the associated point in the residual plot. Move the cursor over the point in the residual plot to display the coordinates. What do the coordinates of the point in the residual plot represent?

c. Describe any pattern you see in the residual plot. What does this indicate about your movable line?

4. In the top work area, move your movable line to different locations, and observe how the residual plot changes. (Note: You might have to select **Menu > Window/Zoom > Zoom – Data** in order to see all of the residuals.)
   a. Find a line where the residual plot has a pattern. Describe the pattern and the relationship between the movable line and the pulse rate data.

   b. Find a line where the residual plot doesn't have a pattern. Compare your movable line to the lines of several other students. Whose line seems to best fit the trend in the data? Explain your thinking.

Move to page 1.4.

On page 1.4, graph the same scatter plot that you graphed on page 1.3.

A linear least squares fitting technique can be used to model data that has a linear trend. Graph the least squares regression line by selecting **Menu > Analyze > Regression > Show Linear (mx + b)**.

5. Select **Menu > Analyze > Residuals > Show Residual Plot** to display the residual plot for the regression line.
   a. Describe the residual plot for the regression line.

   Select **Menu > Analyze > Residuals > Hide Residual** Plot to remove the residual plot.

   Select **Menu > Analyze > Residuals > Show Residual Squares** to display the sum of the squares of the residuals for the regression line.

   b. The least squares linear regression line is the line that minimizes the sum of the squares of the residuals. Given your previous exploration of movable lines and residual squares, does this statement seem to be true? Explain your answer.

c. Interpret the slope of the least squares regression equation in terms of the mean pulse rates. How does your answer compare to your answer to Question 1b?

d. According to some experts, the maximum pulse rate is 220 minus your age, and a healthy pulse rate during, or just after, exercise should be about 60-80% of this number. Assume that a 16 year-old student has a before-exercise mean pulse rate of 68 beats per minute. How does the after-exercise mean pulse rate predicted by the regression equation compare to the after-exercise pulse rate range described by the experts?

Note: To use the regression equation to predict an after-exercise mean pulse rate, press ctrl doc, and select **Add Calculator** to add a Calculator page. Press var and select **stat.regeqn**. In the parentheses, enter a value for the before-exercise mean pulse rate, and press enter.

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Interpreting Linear Models

TI PROFESSIONAL DEVELOPMENT

TEACHER NOTES

Math Objectives

- Students will model a linear relationship between the independent and dependent variables in a data set and analyze graphical representations of the residuals.
- Students will recognize that if a linear model is a good fit for the data, the residual plot will be randomly scattered about the horizontal axis with no obvious curvature or trend.
- Students will model with mathematics (CCSS Mathematical Practices).

Vocabulary

- independent variable
- dependent variable
- scatter plot
- slope
- least squares regression line
- residual

About the Lesson

- This lesson involves graphing a scatter plot and fitting a line to mean pulse rate data collected before and after exercise.
- As a result, students will:
  - Fit a movable line to a scatter plot of mean pulse rates before and after exercise.
  - Interpret the slope and *y*-intercept of the line in terms of the pulse rates.
  - Display and interpret the sum of squares of residuals.
  - Identify large residuals from the scatter plot and movable line and from the residual plot.
  - Graph and interpret the least squares regression line and corresponding residual squares and residual plot.

TI-Nspire™ Navigator™ System

- Use Class Capture to examine different lines used by students to model the trend of the data.
- Use Live Presenter to display graphs of residual squares and residual plots.
- Use Quick Poll to assess student understanding.

TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Grab and drag a line

Lesson Files:

Student Activity

- Interpreting_Linear_Models_Student.doc
- Interpreting_Linear_Models_Student.pdf

TI-Nspire document

- Interpreting_Linear_Models.tns

Discussion Points and Possible Answers

Tech Tip: Using the TI-Nspire™ Teacher Software, you can copy data from a spreadsheet or table and paste it into a Lists & Spreadsheet application. In the Lists & Spreadsheet page, move the cursor to Cell A1, and press **ctrl+v** to paste the data into the spreadsheet. Note that the name for each list must be entered into the top row of each column.

Jackie's class has been studying health and nutrition. One of the students read an article about pulse rates before and after-exercise. The students wondered whether you could predict their after-exercise pulse rates from their before-exercise pulse rates. The class measured their pulse rates before and after exercise for five days. The data in the "before" columns represent the mean pulse rate for the five days at the beginning of class for a student. The entry in the corresponding "after" column represents the mean pulse rate of that student after one minute of doing jumping jacks.
Note: All of the students in Jackie's class are aged 16 or 17.

	Pulse Beats/Min **before** exercise	Pulse Beats/Min **after** exercise			Pulse Beats/Min **before** exercise	Pulse Beats/Min **after** exercise
1	86	164		16	73	144
2	88	164		17	73	136
3	75	140		18	79	145
4	88	160		19	79	141
5	64	137		20	86	150
6	84	136		21	98	156
7	85	154		22	74	136
8	93	140		23	76	122
9	93	164		24	96	160
10	86	156		25	92	145
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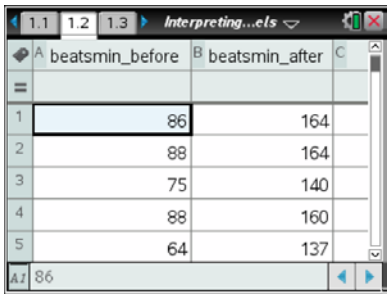

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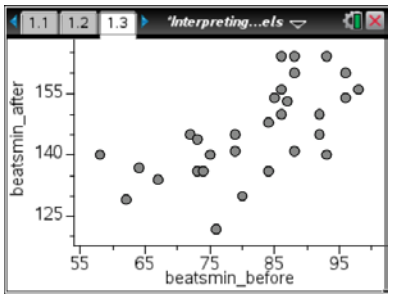
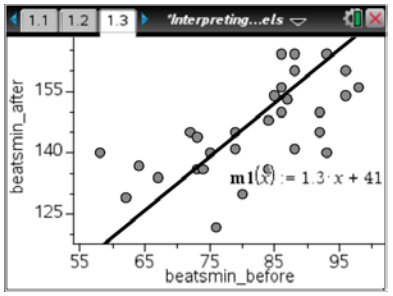
Page 1.3 is a Data & Statistics page. To graph the scatter plot, move the cursor to the "Click to add variable" message near the lower center of the screen. Press ⬚ to display the variables. Select the independent variable.

Move the cursor to the middle of the left side of the screen. When the "Click or Enter to add variable" message appears, press ⬚ to display the variables. Select the dependent variable.

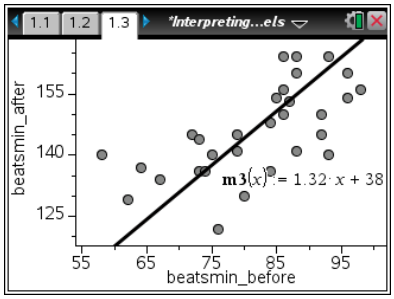


Note: Students can also press tab to display the variables after moving to the Data & Statistics page.

Select **Menu > Analyze > Add Movable Line**. Transform the movable line until it fits the trend in the data well.



- To rotate the line, move the cursor to the graph of the line near the edge of the graph screen. When the rotation symbol (↻) appears, press ctrl ⬚ to grab the line. Use the Touchpad to rotate the graph. When finished, press ⬚ or esc.
- To translate the line, move the cursor to the graph of the line in the center of the screen. When the translation symbol (✣) appears, press ctrl ⬚ to grab the line. Use the Touchpad to translate the graph. When finished, press ⬚ or esc.



1. a. What is the equation of your movable line?

Sample Answer: Answers will vary. One example: **m1**(x) = 1.32 x + 38

b. Interpret the slope of your line in terms of the mean pulse rates.

Sample Answer: Answers will vary. The slope value given in the Sample Answer for Question 1a is 1.32. If the before-exercise mean pulse rate increased by 10 beats per minute, the after-exercise mean pulse rate would increase by about 13 beats per minute.

c. Is the *y*-intercept of your line meaningful? Why or why not?

Sample Answer: The *y*-intercept is not meaningful because the *x*-coordinate of the *y*-intercept would represent a mean pulse rate before exercise of 0 beats per minute.

d. Give the coordinates of a data point that is very close to the line. What after-exercise pulse rate does your line predict for the person whose data point you identified? How far off is this prediction?

Sample Answer: The point (74, 136) is close to my line. The line predicts a mean after-exercise pulse rate of almost 136 beats per minute, while the observed pulse rate was 136 beats per minute.

e. Give the coordinates of a data point that is not very close to the line. What after-exercise pulse rate does your line predict for the person whose data point you identified? How far off is this prediction?

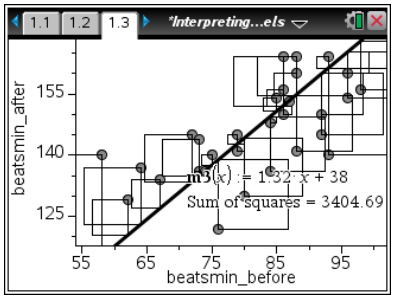
Sample Answer: The point (93,140) is pretty far from the line. The movable line predicts a mean after-exercise pulse rate of approximately 160 beats per minute, which is a difference of 20 beats per minute. This difference is larger than many of the other differences between the observed and the predicted values.

Tech Tip: Moving the cursor over a point in a scatter plot will display the coordinates of the point. The vertical axis scale can be used to estimate an after-exercise pulse rate predicted by a student's movable line.

TI-Nspire Navigator Opportunity: *Class Capture and Live Presenter*
See Note 1 at the end of this lesson.

2. Select **Menu > Analyze > Residuals > Show Residual Squares**.

a. What does the length of the side of each square represent?



Sample Answer: The length is the absolute value of the difference between the actual after-exercise mean pulse rate and the after-exercise mean pulse rate predicted by the movable line.

Teacher Tip: Be sure that students understand that the difference in the *y*-value of a data point (beatsmin_before, observed) and the *y*-value of the ordered pair predicted by the mathematical model (beatsmin_before, predicted) is the value of the residual. Consequently, a residual might be a negative or a positive number and its absolute value is the vertical distance from the data point to the linear model.

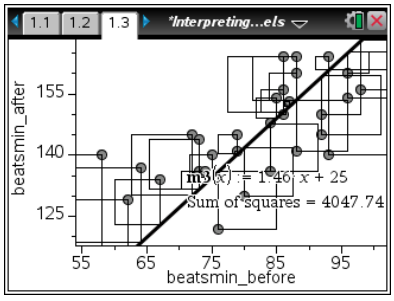
b. What does the area of each residual square represent?

Sample Answer: The area of a residual square is the square of the value of the residual for that particular square.

c. Record the value of the sum of squares for your movable line.

Sample Answer: 3392.48 square units

d. Move your movable line to several different locations. What do you observe about the residual squares and the sum of squares of the residuals?

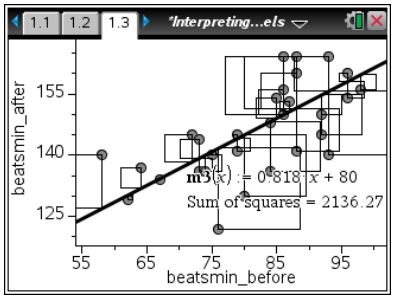


Sample Answer: As the movable line changes, the residual squares change, and the sum of the squares of the residuals change.

e. Change your movable line until the sum of the squares of the residuals is approximately 9,000. Then change the movable line until the sum of the squares is approximately 2,500. What do you observe about the relationship between the sum of the squares of the residuals and the fit of the movable line?

Sample Answer: When the value of the sum of squares is larger, the line does not fit the trend in the data as well. When the value of the sum of squares is smaller, the line is a better fit.

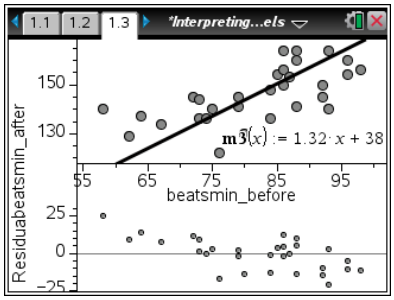
f. Change your movable line until you have the smallest value that you can determine for the sum of the squares of the residuals. What is that sum of squares?



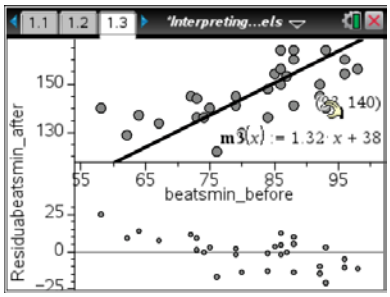
Sample Answer: Sum of Squares = 2136.27 square units

Teacher Tip: Be sure that students understand that when they change the line to try to locate a smaller value for the sum of the residuals squares, they are also trying to determine a line that is as close to all of the data points as possible. The differences between the observed and expected values are reduced.

3. Select **Menu > Analyze > Residuals > Hide Residual Squares**. Move your movable line so that it has the same equation as your answer to Question 1a. Then, select **Menu > Analyze > Residuals > Show Residual Plot.**

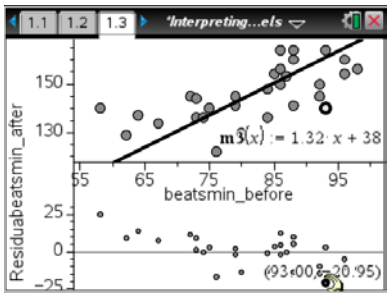


a. In the top work area, move the cursor over the point you identified in Question 1e as a point that is not very close to the line. What do the coordinates of the point represent?



Sample Answer: The point (93,140) represents a before-exercise mean pulse rate of 93 beats per minute and an after-exercise mean pulse rate of 140 beats per minute.

b. Click on this point, and observe the associated point in the residual plot. Move the cursor over the point in the residual plot to display the coordinates. What do the coordinates of the point in the residual plot represent?



Sample Answer: The coordinates of the associated point in the residual plot are (93,-20.95). This indicates that for a before-exercise mean pulse rate of 93 beats per minute, the movable line predicts an after-exercise mean pulse rate that is 20.95 or about 21 beats greater than the observed number of beats (140). The observed value is less than the predicted value. Therefore, the sign of the residual is negative.

Tech Tip: To deselect one or more points, click in an empty location in the screen.

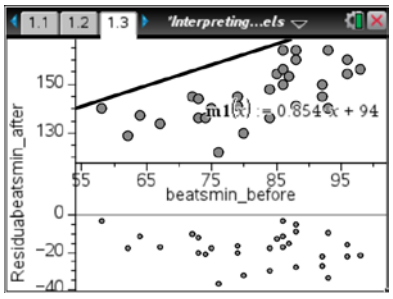
c. Describe any pattern you see in the residual plot. What does this indicate about your movable line?

Sample Answer: For the movable line shown, the residuals for the lowest before-exercise mean pulse rates are positive – the line under-predicts these after-exercise mean pulse rates. Most of the residuals for the largest before-exercise mean pulse rates are negative – the line over-predicts these after-exercise mean pulse rates. There is a somewhat linear pattern in the residual plot. The movable line does not fit the data well.

Teacher Tip: Depending on the students' movable lines, there might or might not be a pattern in their residual plots. If the points in a residual plot are randomly dispersed around the horizontal axis, the mathematical model is likely appropriate for the data. Display a movable line for which the residuals have a pattern (perhaps they appear very linear or all positive or all negative), and help students understand that this suggests that this particular movable line is not a good fit for the data. Ask students to think about how they might move the line in terms of slope and *y*-intercept to remove a pattern in the residual plot. This can reinforce the relationship between the two representations—the equation and the line. The pattern shown in the sample answers for Question 3 suggest that the slope of the movable line should be smaller for a better fit.

4. In the top work area, move your movable line to different locations and observe how the residual plot changes. (Note: You might have to select **Menu > Window/Zoom > Zoom – Data** in order to see all of the residuals.)

   a. Find a line where the residual plot has a pattern. Describe the pattern and the relationship between the movable line and the pulse rate data.

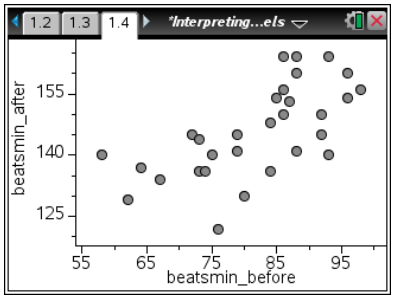


Sample Answer: Students might describe a residual plot where the residuals are nearly all negative, which indicates that the movable line was above most of the data points.

   b. Find a line where the residual plot doesn't have a pattern. Compare your movable line to the lines of several other students. Whose line seems to best fit the trend in the data? Explain your thinking.

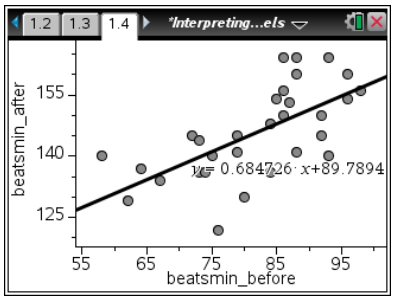
Sample Answers: Reasons for selecting the "best fit" line for the data might include equal number of positive and negative residuals or no pattern in the residual plot.

Move to page 1.4.



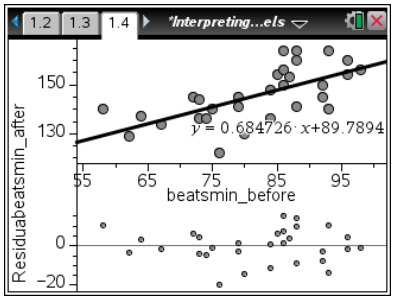
On page 1.4, graph the same scatter plot that you graphed on page 1.3.

A linear least squares fitting technique can be used to model data that has a linear trend. Graph the least squares regression line by selecting **Menu > Analyze > Regression > Show Linear (mx + b)**.



5. Select **Menu > Analyze > Residuals > Show Residual Plot** to display the residual plot for the regression line.
   a. Describe the residual plot for the regression line.

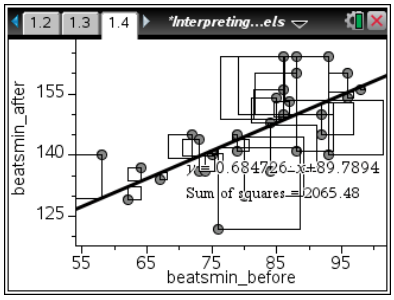
   Sample Answer: The residual plot has no pattern.



Teacher Tip: Be sure that students do not assume that the residual plot will never have a pattern when they use the least squares regression equation to model the data. You might want to follow this activity up with an activity where a quadratic or exponential model is an appropriate model for a data set. If students try to fit a linear model to the data, the residual plot will likely have a curved pattern. This suggests that another model might be a better fit.

Select **Menu > Analyze > Residuals > Hide Residual Plot** to remove the residual plot.

Select **Menu > Analyze > Residuals > Show Residual Squares** to display the sum of the squares of the residuals for the regression line.



b. The least squares linear regression line is the line that minimizes the sum of the squares of the residuals. Given your previous exploration of movable lines and residual squares, does this statement seem to be true? Explain your answer.

Sample Answer: Yes. The sum of the squares of the residuals for my movable lines was always larger than the sum of the squares of the residuals for the least squares regression line, 2065.48 square units.

c. Interpret the slope of the least squares regression equation in terms of the mean pulse rates. How does your answer compare to your answer to Question 1b?

Sample Answer: Answers will vary depending on the slope of the students' movable lines. The slope of the least squares regression equation is approximately 0.68. If the before-exercise mean pulse rate increased by 10 beats per minute, the after-exercise mean pulse rate would increase by about 7 beats per minute. This increase in the after-exercise mean pulse rate is less than that predicted in the sample answer for Question 1b.

d. According to some experts, the maximum pulse rate is 220 minus your age, and a healthy pulse rate during, or just after, exercise should be about 60-80% of this number. Assume that a 16 year-old student has a before-exercise mean pulse rate of 68 beats per minute. How does the after-exercise mean pulse rate predicted by the regression equation compare to the after-exercise pulse rate range described by the experts?

Sample Answer: The least squares regression equation predicts an after-exercise mean pulse rate of approximately 136 beats per minute for this student. 220 – 16 = 204. 60% of 204 is approximately 122 and 80% of 204 is approximately 163. The after-exercise beats per minute predicted by the regression equation (136) falls in this range (122 to 163).

Note: To use the regression equation to predict an after-exercise mean pulse rate, press ctrl doc, and select **Add Calculator** to add a Calculator page. Press var and select **stat.regeqn**. In the parentheses, enter a value for the before-exercise mean pulse rate, and press enter.

TI-Nspire Navigator Opportunity: *Quick Poll*
See Note 2 at the end of this lesson.

Wrap Up

Upon completion of the lesson, the teacher should ensure that students understand:

- What a residual is, how it is represented on a graph, and what information is provided by the sum of squares of residuals and the residual plot.
- If the plot of the residuals has a pattern, the model is not a good fit for the data.

TI-Nspire Navigator

Note 1

Class Capture and Live Presenter

Use Class Capture and Live Presenter while students are working on Questions 1 - 4 to display students' movable lines, sum of squares, and residual plots.

Note 2

Quick Poll

Quick Polls can be used throughout the lesson for formative assessment. Or, send multiple Quick Polls at the end of the lesson to identify any misconceptions that students might have.

Exploring the Normal Curve Family

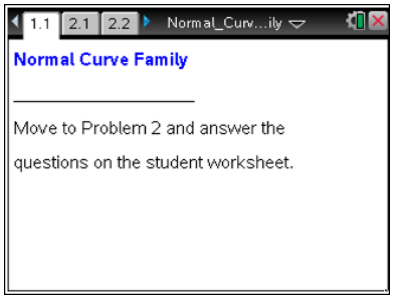
Student Activity

Name _____

Class _____

Open the TI-Nspire™ document *Normal_Curve_Family.tns*.

Have you ever heard a distribution described as *normal* or *approximately normal*? In this activity, you will investigate the family of normal curves and discover the defining characteristics of all curves in the family.



Move to page 2.1.

1. The distributions of many real-world variables can be closely approximated by a normal distribution. The equation of a normal curve is approximately $p(x) \approx \frac{0.4}{\sigma} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$, where μ is the mean and σ is the standard deviation.
   a. Describe the shape, center, and spread of the curve on page 2.1.

   b. Find $p(1)$ when $\mu = 1$ and $\sigma = 1$. Explain how this point relates to the graph.

   c. Use the arrows to change μ and σ. Describe the changes in the graph of the normal curve.

2. The point at which a graph changes from concave up to concave down is called the **point of inflection**. How far is a point of inflection from the center of the graph? Explain how you know.

Move to page 2.2.

3. a. Two characteristics of this curve are the maximum point (center) and the distance from the center to the point of inflection (measure of spread). Use the arrows to change μ and σ. Describe how the parameters in the equation affect the maximum point and why.

b. Predict the center, shape, and spread of the curve if $\mu = 3$ and $\sigma = 2$. Verify your prediction using the sliders.

Move to page 3.1.

4. Consider the dashed curve.
   a. Predict the values for μ and σ that were used to create the graph. Explain why you think your prediction makes sense.

   b. Verify the predictions by typing values into Column B of the spreadsheet. (The dotted line will become solid when you have the correct values.)

Move to page 4.1.

5. a. Describe the axis of symmetry for the curve.

   b. What happens to the axis of symmetry as μ and σ change?

6. a. The length of the segment connecting the point of inflection and the axis of symmetry represents the standard deviation. Describe the changes in the graph as the standard deviation increases.

   b. Compare a normal curve with a mean of –2 and a standard deviation of 1 to a normal curve with a mean of 1 and a standard deviation of 1.

7. a. Calculate the area of one grid box, and then count boxes to approximate the area between the curve and the horizontal axis when $\mu = 0.6$ and $\sigma = 1.8$. (Note that the horizontal scale is marked in 1 unit intervals and the vertical scale is marked in 0.1 unit intervals.)

   b. Change the value of μ. Predict the total area between the curve and the horizontal axis. Verify by counting the boxes.

   c. Set μ to 0, and change the value of σ to 0.5. Use the grid boxes to approximate the area between the curve and the horizontal axis.

   d. Change σ to a new value. Predict the area between the curve and the horizontal axis. Verify by counting the boxes.

8. A normal curve has defining characteristics related to shape, center, spread, and area. What are these characteristics, and how can you recognize them in a graph?

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Exploring the Normal Curve Family

MATH NSPIRED

Math Objectives

- Students will identify the defining characteristics of a normal curve related to shape, center, spread, and area.
- Students will recognize that normal curves form a family whose members share these same characteristics.
- Students will use appropriate tools strategically (CCSS Mathematical Practices).
- Students will model with mathematics (CCSS Mathematical Practices).

Vocabulary

- normal curve
- mean
- point of inflection
- standard deviation

About the Lesson

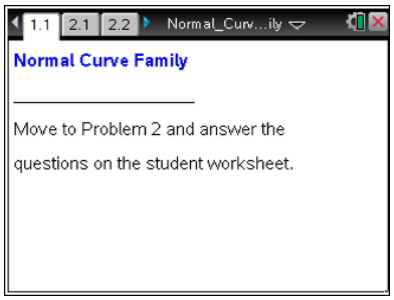
- This lesson involves investigating the relationship of the equation of a normal curve to its graph. As a result, students will:
  - Identify the axis of symmetry as the line $x = \mu$, where μ is the mean of the distribution represented by the normal curve, and the standard deviation as the horizontal distance from that line to the point of inflection.
  - Use a slider to change the values of two parameters, μ and σ, to investigate their effects on the normal curve, noting in particular that μ represents the location of the mean and that σ represents the horizontal distance from the mean to either point of inflection.
  - Estimate the area under a normal curve graphed on a coordinate grid, and investigate the area as the mean and standard deviation are changed.

TI-Nspire™ Navigator™ System

- Send out the *Normal_Curve_Family.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes class captures from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions might be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Normal_Curve_Family_Student.pdf
- Normal_Curve_Family_Student.doc

TI-Nspire document

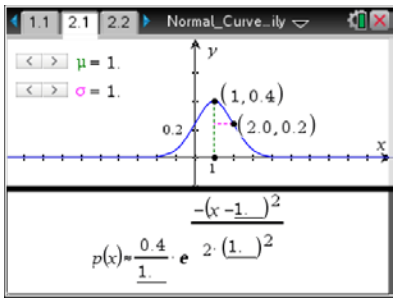
- Normal_Curve_Family.tns

Discussion Points and Possible Answers

Tech Tip: In this activity, students will **not** move the two points on the curve manually. To change the value of μ or σ, students should move the cursor to the left or right arrow displayed on the screen and press ctrl.

Teacher Tip: The initial discussion refers only to the parameters **μ** and **σ** and not to the characteristics of a distribution. That comes into the investigation at Question 7, where the curve is connected to the mean and standard deviation of a distribution.

Move to page 2.1.



1. The distributions of many real-world variables can be closely approximated by a normal distribution. The equation of a normal curve is approximately $p(x) \approx \frac{0.4}{\sigma} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$, where μ is the mean and σ the standard deviation.
   a. Describe the shape, center, and spread of the curve on page 2.1.

   Sample Answers: The curve is mound-shaped (unimodal) and seems to be symmetric to a line through the center—the axis of symmetry. The axis of symmetry is $x = 1$. The spread seems to go from negative infinity to positive infinity, but the curve is bunched up, mostly between –1.5 and 3.5 or –2 and 4. The maximum point, or height, of the curve seems to be about 0.4 at $x = 1$.

Teacher Tip: The actual equation for the normal curve is $p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$.

If you show the equation to students, be sure they recognize that π and *e* are constants. Students might be asked to determine how the equation explains the behavior of the graph as *x* approaches infinity. They should observe that the number *e* raised to a negative power is really 1 over *e* to that power, so as *x* increases, the fraction becomes 1 divided by a very large number. That number will get closer and closer to 0, and the product of a number very close to 0 and 0.4 will also get increasingly closer to 0.

b. Find $p(1)$ when $\mu = 1$ and $\sigma = 1$. Explain how this point relates to the graph.

Answer: $p(1) = 0.4$, which represents the height of the curve at $x = 1$. The point (1, 0.4) is the maximum point on the curve.

c. Use the arrows to change μ and σ. Describe the changes in the graph of the normal curve.

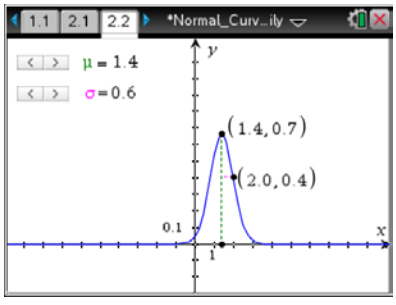
Answer: The graph of the curve shifts horizontally when μ is changed. It moves to the right when μ increases, and moves to the left when μ decreases. When σ is changed, the height of the graph changes.

2. The point at which a graph changes from concave up to concave down is called the **point of inflection**. How far is a point of inflection from the center of the graph? Explain how you know.

Answer: The distance from a point to a line is the perpendicular distance from the point to the line, which is represented by the horizontal segment in the graph. The length of the segment from the axis of symmetry to either point of inflection is the same as the value of σ, the standard deviation. Using the displayed ordered pairs, you can subtract the x-coordinates.

Teacher Tip: To help students understand the points of inflection, you might ask them how they would construct the curve using parts of curves they already know. They might suggest using part of a parabola that opens down and part of an exponential curve. The point at which the two would be glued together is the point of inflection. It can also be described as the point at which the curve, like a bowl with sloped edges, switches from "spilling water" to "holding water." Stress, however, that the curves in the graphs of the normal curves are not really parabolas.

Move to page 2.2.



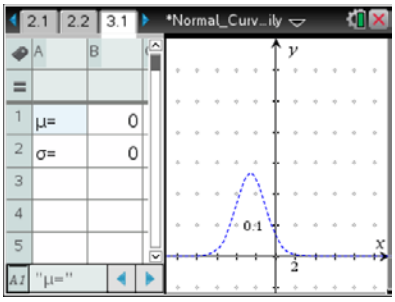
3. a. Two characteristics of this curve are the maximum point (center) and the distance from the center to the point of inflection (measure of spread). Use the arrows to change μ and σ. Describe how the parameters in the equation affect the maximum point and why.

Answer: The height of the maximum point is affected by changing σ. The curve gets "squeezed up" as σ gets smaller. A smaller σ means the points of inflection on either side of the axis of symmetry are closer to the mean. The horizontal location of the maximum point is affected by changing μ.

b. Predict the center, shape, and spread of the curve if $\mu = 3$ and $\sigma = 2$. Verify your prediction using the sliders.

Answer: The center of the curve will be at $x = 3$ on the horizontal axis, and the axis of symmetry will be the line $x = 3$. The curve will be flatter than when the standard deviation is 1, and the tails will still approach but not touch the x-axis. The distance from the axis of symmetry to either point of inflection is 2.

Move to page 3.1.



4. Consider the dashed curve.
   a. Predict the values for μ and σ that were used to create the graph. Explain why you think your prediction makes sense.

Sample Answers: Students might suggest the values are about $\mu = -2.5$ and $\sigma = 1.5$. The value for μ is the x-coordinate of the maximum point on the curve, and the distance from the value of μ to the point of inflection is the value of σ.

Tech Tip: To add or modify the data in a spreadsheet cell, double-tap the cell.

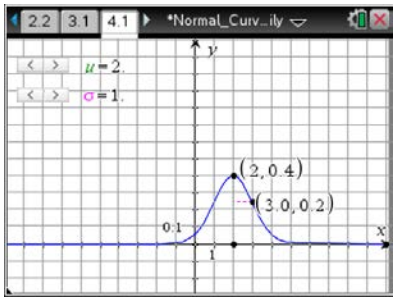
Tech Tip: To hide the keyboard after entering a value into the spreadsheet, press the keyboard down button in the lower right corner.

TI-Nspire Navigator Opportunity: *Quick Poll*
See Note 1 at the end of this lesson.

b. Verify the predictions by typing values into Column B of the spreadsheet. (The dotted line will become solid when you have the correct values.)

Answer: $\mu = -2.5$ and $\sigma = 1.5$

Move to page 4.1.



5. a. Describe the axis of symmetry for the curve.

Answer: The axis of symmetry is a line that divides the curve into two congruent parts. In this case, it is the vertical line that goes through $x = \mu$.

b. What happens to the axis of symmetry as μ and σ change?

Answer: The axis of symmetry is not affected at all by a change in σ. It is determined by μ; the line of symmetry is the vertical line $x = \mu$.

6. a. The length of the segment connecting the point of inflection and the axis of symmetry represents the standard deviation. Describe the changes in the graph as the standard deviation increases.

Answer: As the standard deviation increases, the graph becomes flatter and flatter, with the *y*-coordinate of the peak decreasing proportionately with increases in the value of σ.

b. Compare a normal curve with a mean of –2 and a standard deviation of 1 to a normal curve with a mean of 1 and a standard deviation of 1.

Answer: The curves are congruent. The curve with a mean of 1 could be translated 3 units to the left, and it would then match the curve with a mean of –2 exactly.

7. a. Calculate the area of one grid box, and then count boxes to approximate the area between the curve and the horizontal axis when $\mu = 0.6$ and $\sigma = 1.8$. (Note that the horizontal scale is marked in 1 unit intervals and the vertical scale is marked in 0.1 unit intervals.)

Answer: The area of one grid box is 0.1 by 1 or 0.1 square units. By counting and estimating, the number of rectangles between the curve and the horizontal axis is approximately 9.5, so the total area is approximately 0.95 plus the small parts under the tails as the *x*-values continue to increase or decrease, for a total area of about 1.

Teacher Tip: Students might need to be reminded of the extra area that is not clearly visible and that accumulates as *x* goes to plus and minus infinity. A smaller grid might be a way to help them get a better estimate, which can be done by going to **Menu > Window/Zoom > Window Settings** and resetting the *x*-scale to a smaller value, e.g., 0.5 or 0.25.

Tech Tip: The window settings can be accessed by selecting > **Window/Zoom > Window Settings**.

b. Change the value of μ. Predict the total area between the curve and the horizontal axis. Verify by counting the boxes.

Answer: The value of μ will not change the area because the shifted curve will be congruent to the original; thus areas bounded by the curve and the horizontal axis for both curves will be equal.

c. Set μ to 0, and change the value of σ to 0.5. Use the grid boxes to approximate the area between the curve and the horizontal axis.

Answer: If the *x*-scale is not changed, each rectangle formed by the grid still has an area of 0.1. There are still about 9.5 rectangles that are 1 by 0.1 plus the extra area as the curve continues along the *x*-axis. The total area is approximately 1 square unit.

d. Change σ to a new value. Predict the area between the curve and the horizontal axis. Verify by counting the boxes.

Answer: The area continues to be about 1 square unit.

TI-Nspire Navigator Opportunity: *Quick Poll*
See Note 2 at the end of this lesson.

8. A normal curve has defining characteristics related to shape, center, spread, and area. What are these characteristics and how can you recognize them in a graph?

Answer: (i) The curve is mound-shaped (unimodal) and is symmetric to a line through the axis of symmetry ($x = \mu$).

(ii) The *x*-coordinate of the maximum point is the mean of the distribution. The vertical line through the mean is the axis of symmetry for the curve.

(ii) The standard deviation of the distribution is the horizontal distance from the axis of symmetry to either point of inflection.

(iii) The total area bounded by any normal curve and the horizontal axis is always 1 square unit.

Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- A normal curve has certain defining characteristics. (These characteristics are given in the answer to Question 8.)
- Normal curves form a family of curves whose members share these characteristics.

Assessment

Identify the following as true or false. Be prepared to explain your reasoning in each case.

a. A normal curve can be short and flat or tall and skinny.

Answer: True; a large value of σ creates a short, flat curve, and a small value of σ creates a tall, skinny curve.

b. You can make two normal curves so that one would fit completely inside the other.

Answer: False; the area between every normal curve and the x-axis is 1 square unit, so it is impossible to have one normal curve completely under another.

c. It is possible to create a normal curve such that the area between the curve and the x-axis is more than 1.

Answer: False; the area between every normal curve and the x-axis is 1 square unit.

d. All normal curves are symmetric.

Answer: True; the curves are symmetric about the line $x = \mu$, the mean of the distribution.

e. There is some value of x such that the point $(x, 0)$ is on the normal curve.

Answer: False; if this were true, the curve would touch the x-axis, but that is impossible given the equation of the normal curve. The y-coordinate of a point on the normal curve is never equal to zero.

TI-Nspire Navigator

Note 1

Question 4 part a, *Quick Poll*

Use Quick Poll to gather students' predictions for the values of μ and σ. Tip: Poll the variables one at a time by having them enter just the number. This will minimize the variation in the responses.

Pick one student's value from those submitted and discuss with students why they think it will or will not match the curve graphed.

Note 2

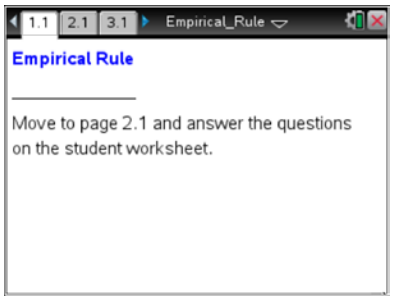
Question 7, *Quick Poll*

To assess student understanding of the area under a normal curve, send one or several open response Quick Polls. For example, "What is the area under a normal curve with $\mu = 5$ and $\sigma = 2$?" Students should always response with "1" or "approximately 1".

Empirical Rule
Student Activity

Name _____
Class _____

Open the TI-Nspire™ document *Empirical_Rule.tns*.



Does any connection exist between 1) the area under the standard normal curve for a given number of standard deviations from the mean, and 2) the area under any member of the family of normal curves for the same number of standard deviations from the mean?

Move to page 2.1.

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

1. The graph in the top work area is called the standard normal curve. The mean is 0, and the standard deviation is 1. The current z-value is 1. The z-value gives the distance from the mean, in numbers of standard deviations, to a boundary of the shaded region. Note that due to the symmetry of the standard normal curve, the point at the left boundary is z = -1.
   a. Drag the point on the *z*-axis in the top work area, and describe what changes.

   b. Drag the point on the *z*-axis back to $z = 1.0$. What is the area of the shaded region?

2. Consider the normal curve in the bottom work area with a mean of 0 and a standard deviation of 2.
   a. How does this graph compare to the graph in the top work area?

   b. *Match the Area:* Drag the point on the *x*-axis of the graph in the bottom work area until the area of the shaded region matches the area of the shaded region in the graph in the top work area as closely as possible. How are the *x*-values (the cut points) of the graph in the bottom work area related to the *z*-value when the areas are similar? Explain why this is reasonable.

   c. Repeat *Match the Area* using each *z*-value below. Describe how the *x*-values (the cut points) are related to the *z*-value when the areas are approximately the same.
      (i) $z = 2$ (ii) $z = 3$

Move to page 3.1.

3. The graph in the top work area is the standard normal curve as originally displayed in the top work area on Page 2.1. The graph in the bottom work area is a normal curve with a mean of 0 and standard deviation controlled by the slider to the left of σ.
   a. Adjust the slider so that the standard deviation in the bottom graph is 1.5, and then change the *x*-value (the cut point) to play *Match the Area* again. How is this *x*-value (cut point) related to the *z*-value shown in the top graph?

   b. With σ equal to 1.5 in the bottom graph, repeat *Match the Area* using each *z*-value below. Compare your answers to those you found in Question 2, part c.
      (i) $z = 2$ (ii) $z = 3$

4. Repeat *Match the Area* with several more choices for σ. Summarize your conclusions about the relationship between the area of the shaded region in the bottom work area and standard deviations.

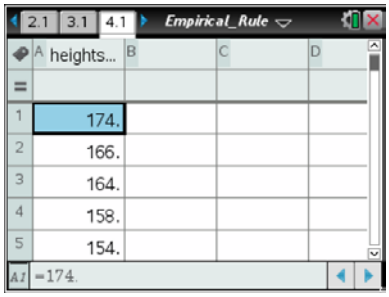
5. Suppose that the mean of a normal curve is $\mu = 2.5$ and that the standard deviation is $\sigma = 1.5$. What are the cut points of the region whose area is approximately 95% of the area under the curve?

Summary: The area, when the cut points of the shaded region are 1 standard deviation from the mean for any member of the family of normal curves, is approximately 0.683 square units; the area, when the cut points of the shaded region are 2 standard deviations from the mean, is approximately 0.954 square units; and the area, when the cut points of the shaded region are 3 standard deviations from the mean, is approximately 0.997 square units. These three areas are approximately 68%, 95%, and 99.7%, respectively, of the total area under any normal curve (1 square unit). These area percentages are often referred to as the "68 – 95 – 99.7 rule" or the Empirical Rule.

Empirical Rule
Student Activity

Name _____
Class _____

Move to page 4.1.



The heights in centimeters of all of the students in a school have been entered into the spreadsheet.

Move to page 4.2.

6. Create a dot plot on this page following these steps:
   - Move the cursor to the bottom work area, and click on "Click to Add Variable."
   - Select the variable **heights_cm**. A dot plot will be graphed.

   a. How would you describe the dot plot?

   Select **Menu > Plot Type > Histogram**.

   b. For the histogram displayed, would you describe the graph in the same way that you described the dot plot? Why or why not?

Move to page 4.3.

Page 4.3 is a Calculator page. Select **Menu > Statistics > Stat Calculations > One-Variable Statistics.** The current number of lists (Num of Lists) shown in the first dialog box is 1. Click **OK**. In the second dialog box, click in the region to the right of X1 List, and select **heights_cm**. Click **OK**.

7. What is the mean height $(\bar{x})$ of the students in the school? Round your answer to the nearest tenth.

8. What is the standard deviation (σx) of the heights of the students in the school? Round your answer to the nearest tenth.

9. Since the graph of the heights of the students in the school is unimodal and approximately symmetric, we can make generalizations about the heights of students at the school based on your explorations of normal curves. Use your rounded values from Questions 7 and 8 to compute your answers.
   a. Find the values of the left and right cut points that are 1 standard deviation from the mean.

   b. What is the range of the heights of the students who represent the central 68% of the population?

   c. What is the range of the heights of the students who represent the central 95% of the population?

   d. What are the heights of the students in the top 2.5% of the population?

   e. A height that is more than 3 standard deviations from the mean is considered to be unusual. Are there any students in this population whose heights are unusual?

Empirical Rule

Math Objectives

- Students will associate the area bounded by a normal curve, the horizontal axis, and a vertical cut point with probability.
- Students will recognize that for any member of the family of normal curves, the percent of area bounded by the normal curve, the horizontal axis, and z = 1, 2, and 3 standard deviations are the same.
- Students will recognize the Empirical Rule can be used to make generalizations about the population given a histogram of values that can be approximated by a normal curve.
- Students will reason abstractly and quantitatively (CCSS Mathematical Practices).

Vocabulary

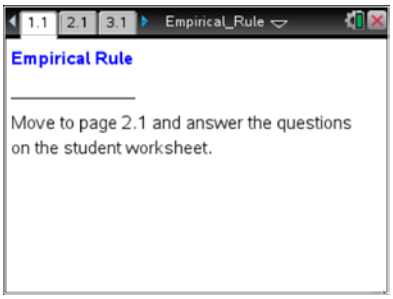
- standard normal curve
- mean
- standard deviation

About the Lesson

- This lesson involves finding the area bounded by the standard normal curve and the horizontal axis for a given number of standard deviations from the mean and comparing this area to the corresponding area for another member of the family of normal curves.
- As a result, students will:
  - Play a *Match the Area* game, and learn that the areas of the regions that are 1, 2, and 3 standard deviations from the mean are approximately 68%, 95%, and 99.7%, respectively, of the total area under the curve regardless of which normal curve is being examined.
  - Change the standard deviation to learn that the area between the cut points determined by any given distance from the mean, when measured in standard deviation units, is the same for any member of the family of normal curves.
  - Apply the Empirical Rule to answer questions about a data set for a population.

TI-Nspire™ Navigator™

- Use Class Capture to examine the values of x (cut points) that match the area under the curve of the graph in the bottom work area to the graph in the top work area.
- Use Quick Poll questions to adjust the pace of the lesson according to student understanding.



TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Grab and drag a point

Lesson Files:

Student Activity

- Empirical_Rule_Student.pdf

TI-Nspire document

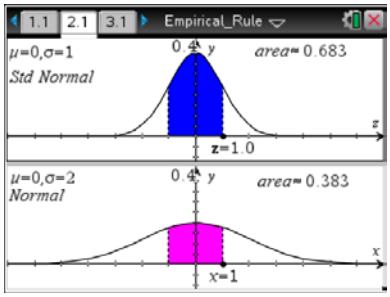
- Empirical_Rule.tns

Discussion Points and Possible Answers

Tech Tip: If students experience difficulty dragging a point, make sure that they have moved the cursor (arrow) until it becomes a hand (☜) getting ready to grab the point. Then press ctrl ☜ to grab the point and close the hand (✊). When finished moving the point, press esc to release the point.

Teacher Tip: The family of normal curves is defined by the function: $p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$. Each different value of μ and σ determines a different function in this family.

Move to page 2.1.



1. The graph in the top work area is called the standard normal curve. The mean is 0 and the standard deviation is 1. The current *z*-value is 1. The *z*-value gives the distance from the mean, in numbers of standard deviations, to a boundary of the shaded region. Note that due to the symmetry of the standard normal curve, the point at the left boundary is $z = -1$.

Teacher Tip: The standard normal curve is defined as a normal curve with a mean of zero and a standard deviation of one. Varying the mean or the standard deviation produces a different member of the family of normal curves.

a. Drag the point on the *z*-axis in the top work area, and describe what changes.

Sample Answer: The shaded region changes and the area changes, increasing as the point is dragged to the right and decreasing as the point is dragged to the left.

b. Drag the point on the *z*-axis back to $z = 1.0$. What is the area of the shaded region?

Answer: Approximately 0.683 square units

Teacher Tip: Be sure students recognize that the areas are all approximate and are accurate only to three decimal places. As the point on the z-axis is moved to the far right, the value for the area might appear as 1 square unit. This value is rounded. The total area under the normal curve bounded by the horizontal axis is 1 square unit. The area value given as the answer to Question 1b (0.683 square units) is 68.3% of the total area.

2. Consider the normal curve in the bottom work area with mean 0 and standard deviation 2.
   a. How does this graph compare to the graph in the top work area?

      Sample Answer: This is the graph of a normal curve having mean 0 and standard deviation 2. The region under the curve bounded by the horizontal axis and between $x = -1$ and $x = 1$ has been shaded. Students might also note that the areas are different.

   b. *Match the Area:* Drag the point on the *x*-axis of the graph in the bottom work area until the area of the shaded region matches the area of the shaded region in the graph in the top work area as closely as possible. How are the *x*-values (the cut points) of the graph in the bottom work area related to the *z*-value when the areas are similar? Explain why this is reasonable.

      Sample Answer: The areas (0.683 square units) match when the cut points are at $x = -2$ and $x = 2$. The distance from the mean to either *x*-value is one standard deviation for this normal curve. The location of the z-value for the standard normal curve is also one standard deviation from the mean. The standard deviation of the graph in the bottom work area is twice the standard deviation of the standard normal curve and the *x*-value of 2 is twice the *z*-value. The graph in the bottom work area is flatter and more spread out, so it makes sense that you would have to move further along the *x*-axis in the bottom graph to have the same area under each curve.

      Teacher Tip: In order to move from the top work area to the bottom work area (or vice versa), click in the desired work area or press ctrl tab.

   c. Repeat *Match the Area* using each *z*-value below. Describe how the *x*-values (the cut points) are related to the *z*-value when the areas are approximately the same.

      Teacher Tip: Be sure students remember the steps for *Match the Area*. Drag the point on the *x*-axis until the area in the bottom graph matches the area in the upper graph as closely as possible.

      (i) $z = 2$

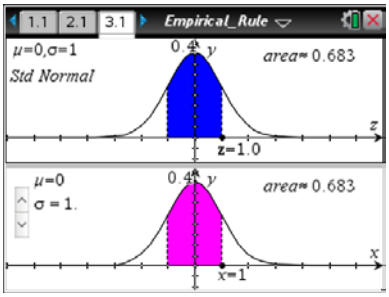
      Sample Answer: When $z = 2$ in the standard normal curve, the corresponding *x*-value that results in the same area, 0.954 square units, in the bottom graph is 4. The distance to either cut point (-4 or 4) is twice the standard deviation of the normal curve in the bottom work area. The distance of the *z*-value from the mean is twice the standard deviation of the standard normal curve.

(ii) $z = 3$

Sample Answer: When $z = 3$ in the standard normal curve, the corresponding x-value that results in the same area, 0.997 square units, in the bottom work area graph is 6. The distance to either cut point (-6 or 6) is three times the standard deviation of the normal curve in the bottom graph. The distance of the z-value from the mean is three times the standard deviation of the standard normal curve.

TI-Nspire Navigator Opportunity: *Class Capture*
See Note 1 at the end of this lesson.

Move to page 3.1.



3. The graph in the top work area is the standard normal curve as originally displayed in the top work area of Page 2.1. The graph in the bottom work area is a normal curve with a mean of 0 and a standard deviation controlled by the slider to the left of σ.

   a. Adjust the slider so that the standard deviation in the bottom graph is 1.5, and then change the x-value to play *Match the Area* again. How is this x-value (cut point) related to the z-value shown in the upper graph?

   Sample Answer: The areas (0.683 square units) match when the x-value is 1.5. The distance to either cut point (-1.5 or 1.5) from the mean is one standard deviation. The z-value in the graph in the top work area is also one standard deviation from the mean.

   b. With σ equal to 1.5 in the bottom graph, repeat *Match the Area* using each z-value below. Compare your answers to those you found in Question 2 part c.
   (i) $z = 2$

   Sample Answer: When $z = 2$ in the standard normal curve, the corresponding x-value that results in the same area, 0.954 square units, in the bottom graph is 3. The distance to either cut point (-3 or 3) from the mean is twice the standard deviation of the normal curve in the bottom graph. The distance of the z-value from the mean is twice the standard deviation of the standard normal curve.

(ii) $z = 3$

Sample Answer: When $z = 3$ in the standard normal curve, the corresponding x-value that results in the same area, 0.997 square units, in the bottom graph is 4.5. The distance to either cut point (-4.5 or 4.5) from the mean is three times the standard deviation of the normal curve in the bottom graph. The distance of the z-value from the mean is three times the standard deviation of the standard normal curve.

Teacher Tip: At this stage, students should recognize the fact that the cut point at the boundary of the shaded region is the product of the standard deviation and the number of standard deviations from the mean.

TI-Nspire Navigator Opportunity: *Quick Poll*
See Note 2 at the end of this lesson.

4. Repeat *Match the Area* with several more choices for σ. Summarize your conclusions about the relationship between the area of the shaded region in the bottom work area and standard deviations.

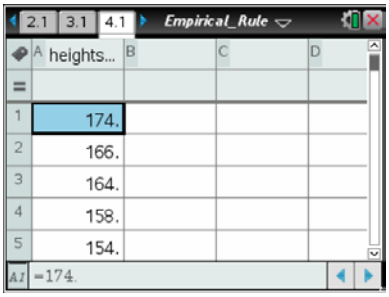
   Sample Answer: The area, when the cut points of the shaded region are 1 standard deviation from the mean for any member of the family of normal curves, is approximately 0.683 square units; the area, when the cut points of the shaded region are 2 standard deviations from the mean, is approximately 0.954 square units; and the area, when the cut points of the shaded region are 3 standard deviations from the mean, is approximately 0.997 square units.

5. Suppose that the mean of a normal curve is $\mu = 2.5$ and that the standard deviation is $\sigma = 1.5$. What are the cut points of the region whose area is approximately 95% of the area under the curve?

   Answer: The left cut point would be -0.5 (2.5 – (1.5)(2) = -0.5), and the right cut point would be 5.5 (2.5 + (1.5)(2) = 5.5).

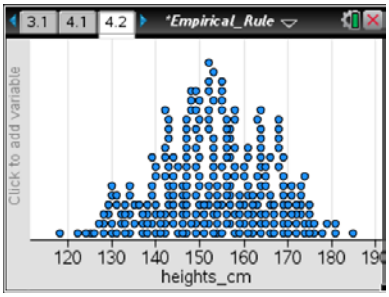
   Summary: The area, when the cut points of the shaded region are 1 standard deviation from the mean for any member of the family of normal curves, is approximately 0.683 square units; the area, when the cut points of the shaded region are 2 standard deviations from the mean, is approximately 0.954 square units; and the area, when the cut points of the shaded region are 3 standard deviations from the mean, is approximately 0.997 square units. These three areas are approximately 68%, 95%, and 99.7%, respectively, of the total area under any normal curve (1 square unit). These area percentages are often referred to as the "68 – 95 – 99.7 rule" or the Empirical Rule.

Move to page 4.1.



The heights in centimeters of all of the students in a school have been entered into the spreadsheet.

Move to page 4.2.



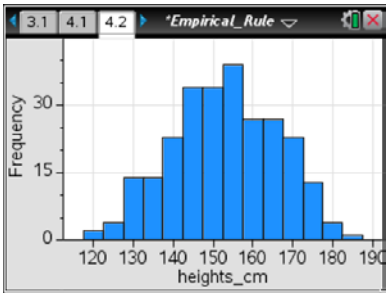
6. Create a dot plot on this page following these steps:
   - Move the cursor to the bottom part of the screen, and click on "Click to Add Variable."
   - Select the variable **heights_cm**. A dot plot will be graphed.

   a. How would you describe the dot plot?

   Sample Answer: The plot appears unimodal and fairly symmetric.

   Select **Menu > Plot Type > Histogram**.

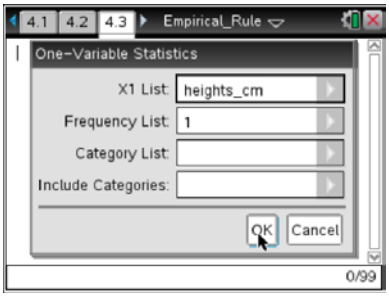
   b. For the histogram displayed, would you describe the graph in the same way that you described the dot plot? Why or why not?



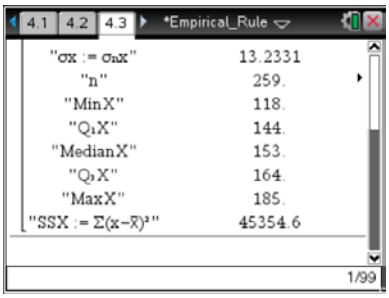
   Sample Answer: Yes. The histogram also appears to be unimodal and fairly symmetric.

Teacher Tip: For data whose graphical representation appears to be unimodal and fairly symmetric, a normal curve provides a good fit for the graph of the data and the mean and standard deviation are the accepted measures of center and spread. For data that are skewed, the median and the IQR (Interquartile range) are the accepted measures of center and spread.

Move to page 4.3.



Page 4.3 is a Calculator page. Select **Menu > Statistics > Stat Calculations > One-Variable Statistics.** The current number of lists (Num of Lists) shown in the first dialog box is 1. Click **OK**. In the second dialog box, click in the region to the right of X1 List and select **heights_cm**. Click **OK**.



7. What is the mean height $(\bar{x})$ of the students in the school? Round your answer to the nearest tenth.

   Answer: Mean = 152.9 cm

8. What is the standard deviation (σx) of the heights of the students in the school? Round your answer to the nearest tenth.

   Answer: Standard deviation = 13.2 cm

   Teacher Tip: We use the Population Standard Deviation, σx, since the data in the spreadsheet are the heights of all of the students in the school (the population).

9. Since the graph of the heights of the students in the school is unimodal and approximately symmetric, you can make generalizations about the heights of students at the school based on your explorations of normal curves. Use your rounded values from Questions 7 and 8 to compute your answers.

   a. Find the values of the left and right cut points that are 1 standard deviation from the mean.

      Answer: Left cut point = 139.7 cm; Right cut point = 166.1 cm

   b. What is the range of the heights of the students who represent the central 68% of the population?

      Answer: 139.7 cm to 166.1 cm

   c. What is the range of the heights of the students who represent the central 95% of the population?

      Answer: 126.5 cm to 179.3 cm

d. What are the heights of the students in the top 2.5% of the population?

Answer: Heights that are more than 179.3 cm

e. A height that is more than 3 standard deviations from the mean is considered to be unusual. Are there any students in this population whose heights are unusual?

Answer: A student height that is less than 113.3 cm or more than 192.5 cm would be unusual. There are no students in this school with a height that is unusual because the minimum student height is 118 cm and the maximum student height is 185 cm.

Wrap Up

Upon completion of the discussion, the teacher should ensure that students are able to understand:

- The Empirical Rule as it relates to areas bounded by the graph of a normal curve and the horizontal axis.
- That regions under normal curves will always have the same area if their cut points are the same number of standard deviations from their means.

TI-Nspire™ Navigator™

Note 1

Question 2, *Class Capture*

Use Class Capture to determine if all students found the correct *x*-values in Question 2c.

Note 2

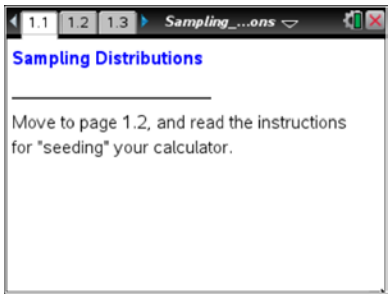
Question 3, *Quick Poll*

Use Open Response Quick Polls to check students' responses for the *x*-values (cut points).

Sampling Distributions
Student Activity

Name _____
Class _____

Open the TI-Nspire™ document *Sampling_Distributions.tns*.



What is a sampling distribution of a statistic? A **sampling distribution** is the distribution of values of a given statistic based on all possible samples of a given size from a given population. In this activity, you will explore and describe the sampling distribution of the sample mean by creating and observing the means of a number of different samples from a given population.

Move to page 1.2.

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

This activity involves generating a number of random samples from a population. In order to avoid having your results be identical to those of another student in the room, it is necessary to "seed" the random number generator. Read the instructions on page 1.2 for seeding your random number generator.

Move to page 2.1.

1. The graph on this page shows a normal distribution with mean 0 and standard deviation 1, representing a population of values. Recall the empirical rule and your knowledge of normal distributions. Predict the shape, center, and spread of a sample randomly selected from this population.

2. Each time you click the arrow (▲) labeled *draw*, you generate a random sample of size 10 from the given population. The elements of the sample will be displayed as points on the *x*-axis. Click to select the first sample. Look particularly at the center and spread of the values selected in the sample. Even though you have selected only 10 values from the population, do they seem to support your predictions in Question 1? Explain.

3. In addition to the 10 values that make up the sample, a vertical line is displayed on the plot. What do you think it represents? Explain your reasoning.

4. Think about the variability among the values that make up your sample and the variability among the vertical $\bar{x}$ lines for several different samples.
   a. Use *draw* to select another sample (still of size 10). Record the value of $\bar{x}$, and write a short description of how the individual values of your sample are distributed (look back at Question 2).

   b. Repeat part a four more times. Describe how the values of $\bar{x}$ vary compared to how the individual values in the samples vary.

   c. Predict the center, spread, and shape of the distribution that would be formed by all $\bar{x}$ values from a large number of samples. Explain.

Move to page 3.1.

5. The top work area on Page 3.1 shows the same population from Questions 1–4. An axis for a new dot plot has been added in the lower work area.
   a. Click *draw* five times, and describe what seems to be happening in the dot plot.

   b. What variable do you think is being plotted in the dot plot?

6. Click *draw* five more times to generate more values in the dot plot. Does the dot plot seem to confirm the predictions you made in Question 4 about the center, spread, and shape of the distributions of the $\bar{x}$ values from a large number of samples? Explain.

7. You know several measures of spread. Think of one of those measures.
   a. Without doing any actual calculations, estimate the value of that measure of spread, first for the set of individual values in the samples themselves, and then for the set of values in the dot plot in the lower screen on Page 3.1.

   b. How do the measures of spread for the individual values and the sample means compare? Explain any differences you see.

Move to page 3.2.

8. The top work area on Page 3.2 is an exact copy of the lower work area on Page 3.1 with which you have been working. The lower work area displays the same data ($\bar{x}$ values from your samples) in a histogram.
   a. Comment on which display seems better for seeing the overall shape of the distribution. Explain your reasoning.

Move back to page 3.1.

   b. Each click of the *draw* arrow will generate ten more samples, and the means of those samples will be added to the plot in the lower work area. Click *draw* until you have about 100 samples, and then look at the graphs on page 3.2. Which graph type seems most appropriate for this larger simulation? Explain.

   c. Describe the shape of the distribution of sample means. Estimate the mean and standard deviation of this distribution.

Move to page 3.3.

The plot on Page 3.3 is an exact copy of the histogram you examined on Page 3.2 but has an "adjustable" normal curve in the window. You can control the appearance of that curve by clicking on the arrows (▲ or ▼) to select a mean and standard deviation.

9. Use the arrows (▲ or ▼) to set the mean and standard deviation to match the estimates you made in Question 8c. Then, if necessary, re-adjust the values so that they fit your histogram as well as possible. Record your final values for mean and standard deviation. Comment on the accuracy of your predictions.

Move to page 4.1.

All of the students in grades 9-12 at a school measured the circumferences of their heads. The *draw* arrow will select different samples of size ten from the school population, and the mean circumference of the students' heads will be displayed in the lower plot.

10. a Use pages 4.1 and 4.2 to repeat the “sample-size-10” explorations you carried out in Questions 8 and 9 with this new population. Describe the sampling distribution of mean head circumferences for samples of size 10 taken from all grades 9-12 students in the school.

Note: Click the reset arrow on page 4.1 to erase an exploration using one sample size in order to begin a new exploration with another sample size.

b. The lower and upper arrows will generate samples of sizes other than 10 by changing the value of *n*. Repeat these explorations once more, this time using a different sample size. Comment on how changing the sample size affects the center, spread, and shape of the distribution of mean head circumference. Be as specific as possible, indicating what happens when the sample size increases and what happens when the sample size decreases.

11. Write a brief description to explain what you learned about a sampling distribution of sample means for someone who did not do this activity.

Sampling Distributions
MATH NSPIRED

Math Objectives

- Students will recognize that the means of different samples from a normal population will vary symmetrically around the mean of the population, with values near the mean occurring more frequently than those further from the mean, but in a narrower interval than that of individual elements of the population.
- Students will recognize that as sample size increases, variability (spread) in the sampling distribution of sample means decreases.
- Students will look for and make use of structure (CCSS Mathematical Practices).
- Students will model with mathematics (CCSS Mathematical Practices).

Vocabulary

- dot plot
- histogram
- mean
- normal distribution
- population
- sample
- sample mean
- sampling distribution
- standard deviation

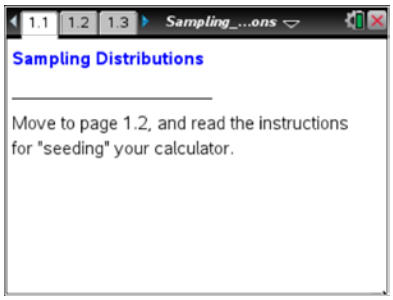
About the Lesson

Note that this lesson is not about establishing the central limit theorem but rather is focused on helping students understand what a sampling distribution is. This would be a good activity prior to introducing the central limit theorem.

- This lesson involves examining samples from a normal population and observing the distribution of the means of those samples.
- As a result, students will:
  - Understand that the sample mean varies from sample to sample, having its own distribution.
  - Estimate descriptive measures for the sampling distribution, and use those measures to approximate the simulated sampling distribution by selecting the mean and standard deviation for overlaying a normal curve.

TI-Nspire™ Navigator™ System

- Send the TI-Nspire document to students.
- Use Class Capture to display multiple distributions.
- Use Quick Poll to compare student sample means.



TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Operate a minimized slider

Tech Tips:

- Make sure the font size on your TI-Nspire handhelds is set to Medium.

Lesson Files:

Student Activity

Sampling_Distributions_Student.pdf

Sampling_Distributions_Student.doc

TI-Nspire document

Sampling_Distributions.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

Prerequisite knowledge

- Normal distributions and the empirical rule
- Random samples
- Descriptive measures (mean and standard deviation)

Prerequisite Activities

- Normal Curve Family
- Z-Scores

Discussion Points and Possible Answers

Tech Tip: Page 1.2 gives instructions on how to seed the random number generator on the TI-Nspire. Page 1.3 is a *Calculator* page for the seeding process. Ensuring that students carry out this step will prevent students from generating identical data. (Syntax: RandSeed #, where # is a number unique to each student.) To complete the command, press enter.

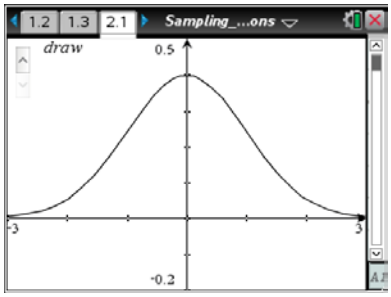
Teacher Tip: The main goal of Questions 1–5 is to have students realize that the sample mean is itself a variable that has a distribution whose shape, center, and spread can be described in its own right.

By thinking about the averaging process, students should conclude that the set of means should have a center near the population mean but should be less variable than the values that make up the population. It is easier to get a single value from the population that is, say, above $x = 2$ than it is to get 10 separate values whose mean is above $x = 2$.

The remainder of the lesson provides simulation experiences aimed at quantifying these properties, at least approximately.

Tech Tip: Page 2.1 initially shows only a normal density curve and minimized slider labeled “draw.” Instruct students to use only the “up” arrow on the slider as they proceed through this lesson.

Move to page 2.1.



1. The graph on this page shows a normal distribution with mean 0 and standard deviation 1, representing a population of values. Recall the empirical rule and your knowledge of normal distributions. Predict the shape, center and spread of a sample randomly selected from this population.

   Sample Answers: Sample values will bounce around, with some above 0 and some below 0. There will be no real pattern, but values very near 3 or –3 will be rare.

Teacher Tip: The elements that make up the sample come from the population. Thus, the population's characteristics should be reflected in the distribution of those sample elements. The values of individual elements in samples should fall approximately symmetrically around 0, with a mean near 0. It will be rare to find values as large as 3 or as small as –3, but values as extreme as –2 or 2 should occur occasionally. Discuss these ideas after students have completed Question 2.

2. Each time you click the arrow (▲) labeled *draw*, you generate a random sample of size 10 from the given population. The elements of the sample will be displayed as points on the *x*-axis. Click to select the first sample. Look particularly at the center and spread of the values selected in the sample. Even though you have selected only 10 values from the population, do they seem to support your predictions in Question 1? Explain.

   Sample Answers: For most students, the answer will be yes, at least somewhat. For example: The values are not quite symmetrical around 0, but the prediction about not often getting close to 3 or –3 was right. The high value appears to be around 1.7, and the low is about –1.9, with four values below the mean and six above it. That all seems reasonable and matches the prediction pretty well.

3. In addition to the 10 values that make up the sample, a vertical line is displayed on the plot. What do you think it represents? Explain your reasoning.

   Sample Answers: It is labeled $\bar{x}$ and appears to be around the middle of the sample, so it represents the mean of the sample. If you estimated the mean of the distribution or the "balance point," it would be about where $\bar{x}$ falls.

Teacher Tip: Be sure students recognize that the plotted line is the mean and not the median. It might be worthwhile to have students verify that the line is not exactly midway between the fifth and sixth dots in the sample.

Teacher Tip: To help students begin to see the variability among values of $\bar{x}$, you might want to have the class share their graphs and/or values of $\bar{x}$ with each other after completing Question 3.

TI-Nspire Navigator Opportunity: *Class Capture*
See Note 1 at the end of the lesson.

4. Think about the variability among the values that make up your sample and the variability among the vertical $\bar{x}$ lines for several different samples.
   a. Use *draw* to select another sample (still of size 10). Record the value of $\bar{x}$, and write a short description of how the individual values of your sample are distributed (look back at Question 2).

      Sample Answers: The values are somewhat similar to those in Question 2 but not exactly the same. They still bounce around 0 and stay away from 3 or –3. The high and low values changed. $\bar{x}$ is 0.262.

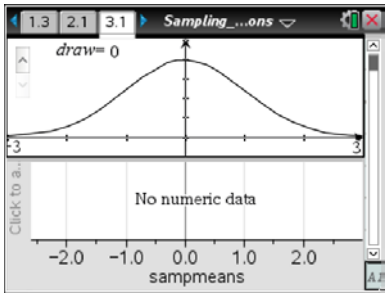
   b. Repeat part a four more times. Describe how the values of $\bar{x}$ vary compared to how the individual values in the samples vary.

      Sample Answers: The individual values remain similar to those in Question 2 but not exactly the same. They still bounce around 0 and, for the most part, still stay away from 3 or –3. The high and low values change for each sample. $\bar{x}$ seems to vary a lot less than the individual values in the sample. Some $\bar{x}$ values fall above 0, and some fall below 0, but none are anywhere near the high and low values for the individual values.

   c. Predict the center, spread, and shape of the distribution that would be formed by the $\bar{x}$ values from a large number of samples. Explain.

      Sample Answers: The $\bar{x}$ values should fall roughly symmetrically around 0. The mean of a sample of size 10 will fall somewhere in the "middle" of the 10 values that make up the sample itself, so $\bar{x}$ should not be very far from 0. Getting a really large mean would require that all 10 individual values were really large, and, based on the answers to parts *a* and *b*, that does not seem likely.

Move to page 3.1.



5. The top work area on page 3.1 shows the same population from Questions 1–4. An axis for a new dot plot has been added in the lower work area.
   a. Click *draw* five times, and describe what seems to be happening in the dot plot.

      Sample Answers: Each click produces a new value plotted in the dot plot directly below the value of $\bar{x}$ in the sample in the upper screen.

b. What variable do you think is being plotted in the dot plot?

Sample Answers: The variable is $\bar{x}$, the sample mean.

6. Click *draw* five more times to generate more values in the dot plot. Does the dot plot seem to confirm the predictions you made in Question 4 about the center, spread, and shape of the distributions of the $\bar{x}$ values from a large number of samples? Explain.

Sample Answers: Yes. The values are accumulating on either side of 0, roughly symmetrically. It looks as though the center of this set of values might be 0, and the spread is noticeably smaller than that of any of the individual samples themselves.

7. You know several measures of spread. Think of one of those measures.
   a. Without doing any actual calculations, estimate the value of that measure of spread, first for the set of individual values in the samples themselves, and then for the set of values in the dot plot in the lower screen on Page 3.1.

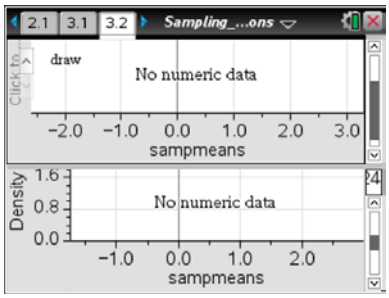
Sample Answers: IQR (interquartile range) describes the spread of the middle half of the values being examined. An estimate of the IQR for the individual values in the samples is about 2. For the dot plot of $\bar{x}$, the IQR seems to be less than 1, maybe 0.5.

   b. How do the measures of spread for the individual elements and the sample means compare? Explain any differences you see.

Sample Answers: The IQR for sample means is definitely less than the IQR for the individual elements in the samples. Since the sample means are always "in the middle of the sample," they do not bounce around as much as the individual values in the sample.

Teacher Tip: Be sure students understand that the mean of the sample, $\bar{x}$, represents a measure of the center, and high and low individual values have been "averaged out" toward that center. This decrease in variability is very visible in comparing the distribution of sample means with the population distribution. The extremes in the tails of the population visible in the top screen on Page 3.1 that would occur in a sample have been averaged with the other values in the sample, and consequently, the spread is smaller for the distribution of sample means displayed in the lower screen on Page 3.1.

Move to page 3.2.



8. The top work area of Page 3.2 is an exact copy of the lower work area on Page 3.1 with which you have been working. The lower work area displays the same data ($\bar{x}$ values from your samples) in a histogram.

Teacher Tip: When a histogram is graphed, the y-axis scale can be set to Frequency, Percent, or Density. When the scale on the vertical axis is density, the histogram has been scaled so that the total area of the histogram is 1 square unit.

Tech Tip: Depending upon the sample size and number of draws, the vertical axis on page 4.2 may need to be adjusted to display all of the histogram. Grab and drag a tic mark on the vertical axis to adjust, as needed.

a. Comment on which display seems better for seeing the overall shape of the distribution. Explain your reasoning.

Sample Answers: Answers will vary. The dot plot may appear better if the histogram's bars are separated and/or short.

Move back to page 3.1.

b. Each click of the *draw* arrow will generate ten more samples, and the means of those samples will be added to the plot in the lower work area. Click *draw* until you have about 100 samples, and then look at the graphs on page 3.2**.** Which graph type seems most appropriate for this larger simulation? Explain.

Sample Answers: Answers may vary, but the histogram is likely the better display of the overall shape of the distribution. The histogram appears less cluttered than the 100-point dot plot.

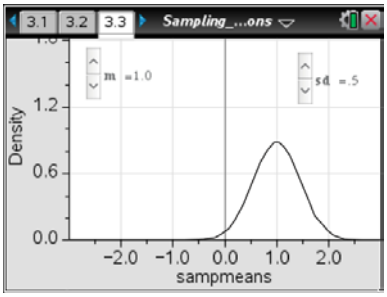
c. Describe the shape of the distribution of sample means. Estimate the mean and standard deviation of this distribution.

Sample Answers: It appears symmetric and mound-shaped, approximately normally distributed. The mean is approximately 0. The standard deviation might be 0.5.

Teacher Tip: While it is not a major point of the lesson, students should become aware that histograms tend to be better representations of data when there are more data present, since histograms display values in a "grouped" manner. Dot plots involve no grouping, so they do better where there are few data.

TI-Nspire Navigator Opportunity: *Class Capture and Quick Poll*
See Notes 2 and 3 at the end of the lesson.

Move to page 3.3.

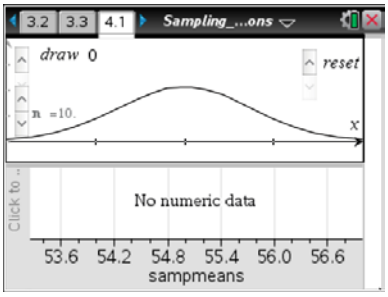


The plot on Page 3.3 is an exact copy of the histogram you examined on Page 3.2 but has an "adjustable" normal curve in the window. You control the appearance of that curve by clicking on the arrows (▲ or ▼) to select a mean and standard deviation.

9. Use the arrows (▲ or ▼) to set the mean and standard deviation to match the estimates you made in Question 8c. Then, if necessary, re-adjust the values so that they fit your histogram as well as possible. Record your final values for mean and standard deviation. Comment on the accuracy of your predictions.

   Sample Answers: The mean was close, but the standard deviation is even smaller than my guess. The actual standard deviation value is more like 0.3.

Move to page 4.1.



Teacher Tip: The sample size should not be changed once the student starts to draw samples in a particular exploration.

All of the students in grades 9-12 at a school measured the circumferences of their heads. The *draw* arrow will select different samples of size ten from the school population, and the mean circumference of the students' heads will be displayed in the lower plot.

10. a Use pages 4.1 and 4.2 to repeat the "sample-size-10" explorations you carried out in Questions 8 and 9 with this new population. Describe the sampling distribution of mean head circumferences for samples of size 10 taken from all grades 9-12 students in the school.

Sample Answers: The means of the head circumferences for 10 students appear to be around 55 and are more concentrated than the distribution of individual head sizes of the high school students (smaller standard deviation, around 0.2 or 0.3). The shape appears roughly symmetric and mound-shaped.

Note: Click the reset arrow on page 4.1 to erase an exploration using one sample size in order to begin a new exploration with another sample size.

b. The lower and upper arrows will generate samples of sizes other than 10 by changing the value of *n*. Repeat these explorations once more, this time using a different sample size. Comment on how changing the sample size affects the center, spread, and shape of the distribution of mean head circumference. Be as specific as possible, indicating what happens when the sample size increases and what happens when the sample size decreases.

Sample Answers: The overall results are the same, with the exception of spread. Larger samples lead to smaller spreads in the sampling distribution of mean head circumference. Smaller samples let the mean head size vary more.

11. Write a brief description to explain what you learned about a sampling distribution of sample means for someone who did not do this activity.

Sample Answers: Student responses should mention that when a random sample is drawn from a population, its sample mean can be calculated. Repeated samplings give a set of sample means that can be plotted to make a simulated sampling distribution. This distribution will have about the same mean as the original population and will be symmetric around that mean, but its spread will be much smaller than that of the original population with smaller spreads occurring for larger sample sizes.

Wrap Up

Upon completion of the lesson, the teacher should ensure that students are able to understand:

- Elements sampled from a normal population vary according to that normal distribution.
- Means of different samples of a fixed size from a given population vary but differently from the individual elements from the population.
- The simulated sampling distribution of sample means looks approximately normally distributed.
- As sample size increases, variability in the sampling distribution of sample means decreases.

TI-Nspire Navigator

Note 1

Question 3, Class Capture and Quick Poll

A Class Capture would allow students to see other results and note the variability. Another good alternative would be to send a Quick Poll to collect each student's displayed $\bar{x}$ value.

Note 2

Question 8, Class Capture

Using Class Capture can reinforce the idea that sample means vary from sample to sample, but that they do so in a somewhat predictable manner. Students should notice that while their individual graphs will be different in detail, most will be centered somewhere near 0, and the spreads of their plots will be about the same.

Note 3

Before Question 9, Quick Poll

Send students a screen shot of page 3.3 and ask them to predict what the mean and standard deviation should be. Show the results, without comment. Have them take 5 minutes to convince a partner that their prediction is correct. Then resend the Quick Poll. Show the results and have students discuss what they were thinking when they made the prediction. Then go to page 3.3 and have them test their predictions.

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Conditional Probability

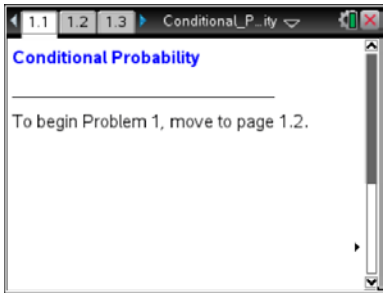
Student Activity

Name _____

Class _____

Open the TI-Nspire document *Conditional_Probability.tns.*

Sometimes additional information can help you narrow the probability that an outcome will occur. This activity allows you to investigate this situation and to see how extra information can make a difference.



In 1992, *Life* magazine published an article entitled "If Women Ran America" which reported the results of a poll of U.S. men and women asked whether the problem of unequal pay for equal work is a serious one in our country. Suppose the poll was given to 44 people, 20 males and 24 females, and that 26 of the people polled agreed that the problem of unequal pay for equal work is serious.

1. Suppose further that 10 of the males agreed that the problem is serious.
   a. Indicate which of the table cells below you could fill in with this information.

Gender/ problem	Yes	No	Row Totals
Male			
Female			
Column Totals			

Move to page 1.2.

   b. On this Lists & Spreadsheet page, enter 10 into the cell representing the number of males who agree the problem is serious, and compare the resulting table to your answer to part a.

2. a. If a person is chosen randomly from the 44 people, what is the probability that the person is a male?

   b. What is the probability that the person is male and the person agrees that the problem is serious?

Move to page 1.3.

3. Page 1.3 shows both the table and a graphical representation of the data in the table. Select the bars in the graph.
   a. Based on the probabilities you see, which outcome is most likely, and what is the probability of that outcome?

b. The two blue bars are the same height. Do they represent the same probabilities? Why or why not?

4. What is the probability that a person chosen at random from those who agree the problem is serious is a male? Explain how you can get this answer from the table and from the graph.

5. Assume the row and column totals remain fixed (that is, there are a total of 44 people in the survey, 24 are female, and 26 of the 44 agree that the problem of unequal pay for equal work is serious. A person is chosen at random from the 44 people, and you know that the person chosen agrees that the problem of unequal pay for equal work is serious. Given this information, enter different values in the table to find the following:
   a. The maximum probability that the person is a male. Explain why this is the maximum.

   b. The minimum probability that the person is a male. Explain why this is the minimum.

Suppose 8 men agreed that the problem is serious. Enter 8 in the appropriate cell in the table.

Move to page 1.4.

6. Explain the differences in the two graphs.

7. Identify the graph you would use to answer each of the following questions, and then answer the question. A newspaper randomly chooses a person to be interviewed from the 44 who were given the poll. What is the probability that:
   a. The person agrees that the problem of unequal pay for equal work is serious, given that the person is male.

   b. The person is male, given the person does not agree that the problem of unequal pay for equal work is serious.

c. The person does not agree that the problem of unequal pay for equal work is serious.

d. The person does not agree that the problem of unequal pay for equal work is serious given that the person is female.

e. The person is male and the person agrees that the problem of unequal pay for equal work is serious.

f. The person is female or the person agrees that the problem of unequal pay for equal work is serious.

8. Some probability questions ask for the probability of a single outcome out of the total number possible. Some ask for the probability of a single outcome with a given condition. Others ask for the probability of an outcome that has compound (satisfies a and/or b) conditions. Categorize the situations from Question 7 into the table below according to the nature of the question.

Question	Single outcome out of total possible	Single outcome with a given condition	Outcome with compound conditions
a			
b			
c			
d			
e			
f			

9. a. Describe how you would identify a probability question where the denominator is not the total number of outcomes.

b. If A and B are two distinct outcomes, what is the difference between the probability of A given B and the probability of B given A?

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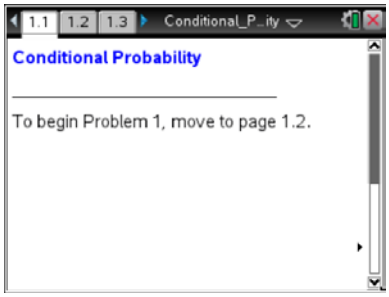
Conditional Probability

MATH NSPIRED

Math Objectives

- Students will identify the difference between the probability of an outcome and the conditional probability of an outcome.
- Students will interpret information presented in a two-way table and in a corresponding bar graph.
- Students will reason abstractly and quantitatively (CCSS Mathematical Practices).



Vocabulary

- conditional probability
- probability
- two-way table

About the Lesson

- This lesson involves thinking about probability when additional information is given. As a result, students will:
  - Investigate probability questions using tabular and graphical information.
  - Explain why a two-way table with two rows and two columns with fixed row and column totals needs only one input to determine the others.
  - Answer questions about the probability of an outcome using data from a two-way table.
  - Use bar graphs separated according to categories to answer probabilities and connect these graphs to information of the form P(A|B).
  - Choose between information presented as the probability of A given B and the probability of B given A (A|B and B|A) to answer specific probability questions.

Tech Tips:

- This activity includes class captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire Apps. Slight variations to these directions might be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

TI-Nspire™ Navigator™

- Send out the *Conditional_Probability.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Lesson Files:

Student Activity

- Conditional_Probability_Student.pdf
- Conditional_Probability_Student.doc

TI-Nspire document

- Conditional_Probability.tns

Activity Materials

- Compatible TI Technologies : TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software

Discussion Points and Possible Answers

Teacher Tip: The lesson would be a good precursor to lay the foundation for the formal definition of conditional probability, $P(A \mid B) = \frac{P(A \cap B)}{P(B)}$ or work with Baye's Theorem. However, for this lesson, students should at least be familiar with the concept of probability.
This activity lends itself to the use of PublishView, which gives you an opportunity to display the two-way table (Page 1.2) and the two bar graphs (Page 1.4) simultaneously so the students can manipulate the two-way table and see how the two sets of bar graphs change dynamically.

Teacher Tip: The lesson is based on an actual poll reported in the June 1992 *Life* magazine article "If Women Ran America." One possible extension at the end of the lesson might be to have students take a poll and compare the results today from those in 1992.

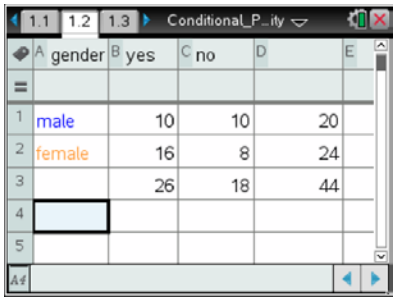
In 1992, *Life* magazine published an article entitled "If Women Ran America", which reported the results of a poll of U.S. men and women asked whether the problem of unequal pay for equal work is a serious one in our country. Suppose the poll was given to 44 people, 20 males and 24 females, and that 26 of the people polled agreed that the problem of unequal pay for equal work is serious.

1. Suppose further that 10 of the males agreed the problem is serious.
   a. Indicate which of the table cells below you could fill in with this information.

Sample Answers:

Gender/ problem	yes	No	Row Totals
Male	10	10	20
Female	16	8	24
Column Totals	26	18	44

Move to page 1.2.



   b. On this Lists & Spreadsheet page, enter 10 into the cell representing the number of males who agree the problem is serious, and compare the resulting table to your answer to part a.

Sample Answers: The worksheet table and the table in the TI-Nspire document should match. Note that one entry in any cell will determine the other cell because the totals for the row and column containing that cell have to be preserved.

Tech Tip: To hide the keyboard after entering a value into the spreadsheet, press the keyboard down button in the lower right corner .

Tech Tip: To add or modify the data in a spreadsheet cell, double-tap the cell.

Tech Tip: Students might want to use the calculator Scratchpad to find the probabilities in question 2.

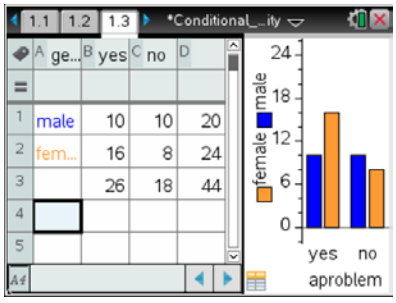
2. a. If a person is chosen randomly from the 44 people, what is the probability that the person is a male?

Sample Answer: 20/44 or 0.4545…

b. What is the probability that the person is male and the person agrees the problem is serious?

Sample Answer: $\frac{10}{44}$ or 0.227273…

Move to page 1.3.



3. Page 1.3 shows both the table and a graphical representation of the data in the table. Select the bars in the graph.
   a. Based on the probabilities you see, which outcome is most likely, and what is the probability of that outcome?

Sample Answer: The outcome that is most likely (0.615 or 61.5%) is a female who agrees the problem is serious.

Teacher Tip: Students might think that the highest bar will always represent the greatest probability of occurring. The next question should address this concern, but it is important to be sure this possible misconception is made clear.

b. The two blue bars are the same height. Do they represent the same probabilities? Why or why not?

Sample Answer: The frequency of both bars is 10, but they represent different things. The blue bar to the left represents the 10 males of the 26 (38.5%) people who answered yes, while the blue bar to the right represents the 10 males out of the total number, 18, (55.6%) who said no.

4. What is the probability that a person chosen at random from those who agree the problem is serious is a male? Explain how you can get this answer from the table and from the graph.

Sample Answer: 10 out of 26 or 38.5% are male, given the person agrees the problem is serious. From the table, use the "yes" column total for the denominator, and use the number of males in that column for the numerator. Using the graph, you would go to the two bars over the label "yes," and choose the bar representing the males.

5. Assume the row and column totals remain fixed (that is, there are a total of 44 people in the survey, 24 are female and 26 of the 44 agree that the problem of unequal pay for equal work is serious. A person is chosen at random from the 44 people, and you know that the person chosen agrees that the problem of unequal pay for equal work is serious. Given this information, enter different values in the table to find the following:
   a. The maximum probability that the person is a male. Explain why this is the maximum.

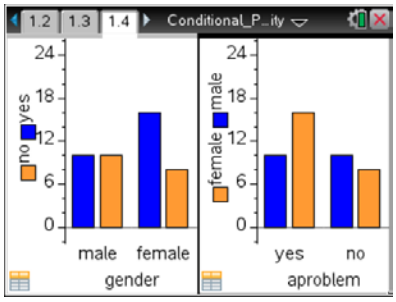
Sample Answer: The maximum possible value for the cell representing male and agreeing the problem is serious is 20 because the total number of males is 20. There are 26 people all together who answered ‘yes’ to the survey. Thus, the maximum probability the person is a male is 20/26 or about 0.769231 (76.9%).

   b. The minimum probability that the person is a male. Explain why this is the minimum.

Sample Answer: The minimum possible value for the cell representing male and agreeing the problem is serious is 2 because there are 24 females and a total of 26 people who answered ‘yes’ to the survey. Thus, the minimum probability the person is a male is 2/26 or about 0.076923 (7.7%).

Suppose eight men agreed that the problem is serious. Enter 8 in the appropriate cell in the table.

Move to page 1.4.



6. Explain the differences in the two graphs.

Sample Answer: The graph in the left panel assumes you know whether the person is a male or a female and from that assumption, shows the probability the person thinks the problem of unequal pay for equal work is serious (assumed: gender; probability: yes/no). The graph in the right panel assumes you know whether the person agrees or does not agree that the problem is serious and based on that knowledge, shows the probability the person is male or female (assumed yes/no; probability: gender).

Teacher Tip: This is a good place to have a discussion about what information is considered "given" or "assumed" in each set of bar graphs.

7. Identify the graph you would use to answer each of the following questions, and then answer the question. A newspaper randomly chooses a person to be interviewed from the 44 who were given the poll. What is the probability that:

   a. The person agrees that the problem of unequal pay for equal work is serious, given that the person is male.

   Sample Answer: The panel on the left, split by gender on the horizontal axis; $\frac{8}{20}$ = 40%.

   b. The person is male, given the person does not agree that the problem of unequal pay for equal work is serious.

   Sample Answer: The panel on the right, split by yes or no to whether the problem is serious on the horizontal axis: $\frac{12}{18}$ or 66.7%.

   c. The person does not agree that the problem of unequal pay for equal work is serious.

   Sample Answer: Either graph would work as you would have to read the frequencies from two of the bars to capture both males and females who answered no to the question of whether the problem is serious and then divide by the total number of people in the survey to obtain 18/44=40.9%.

d. The person does not agree that the problem of unequal pay for equal work is serious given that the person is female.

Sample Answer: The panel on the left, split by gender: $\frac{6}{24}$ or 25%.

e. The person is male and the person agrees that the problem of unequal pay for equal work is serious.

Sample Answers: Either panel, looking for both male and the answer yes to whether the problem is serious. But the denominator is 44, which has to come from the total of all the people surveyed; $\frac{8}{44}$ = 18.2%.

f. The person is female or the person agrees that the problem of unequal pay for equal work is serious.

Sample Answer: Either panel can give the answer by adding up the number who are female and who answered yes to whether the problem is serious. Students should be careful not to count the overlap between females and those who answered yes; $\frac{32}{44}$ = 72.7%.

8. Some probability questions ask for the probability of a single outcome out of the total number possible. Some ask for the probability of a single outcome with a given condition. Others ask for the probability of an outcome that has compound (satisfies a and/or b) conditions. Categorize the situations from Question 7 into the table below according to the nature of the question.

Sample Answers:

Question	Single outcome out of total possible	Single outcome with a given condition	Outcome with compound conditions
a		x	
b		x	
c	x		
d		x	
e			x
f			x

Teacher Tip: You might want to spend more time exploring *P*(A and B) and *P*(A or B) using the data in the table at a later time. The focus of this activity is just on conditional probability.

Teacher Tip: This activity does not use the formal notation: $P(A|B)$. If you choose to introduce the notation it might be better to wait until the end of the activity in order to make sure the concept is well understood before students have to decipher the notation. In many situations, the words should enable students to understand when a conditional probability is involved.

9. a. Describe how you would identify a probability question where the denominator is not the total number of outcomes.

Sample Answer: When the question is based on knowing some given information, you use the subset of the total number of outcomes that specifies that given set; for example, when the problem says, given A, find the probability of B.

b. If A and B are two distinct outcomes, what is the difference between the probability of A given B and the probability of B given A?

Sample Answer: The probability of A given B says you only look for As in the set of all possible Bs. The probability of B given A says you look for Bs in the set of all possible As. The numerator in both cases will be the same, the intersection of A and B, but the denominator in the first case will be the number of outcomes that are B and, in the second case, the number of outcomes that are A.

Teacher Tip: You might want to put the two-way table on the board and have the students display the bar graphs on their handhelds. Make sure they understand how the bar graphs connect with the table. In one case when you are given the gender, you are considering the row totals. In the other case, when you are given the knowledge "if a person agrees the problem is serious" then you are considering the column totals.

Extension

The actual results of the survey were that $\frac{1}{2}$ of the men agreed the problem of unequal pay for equal work was serious, while $\frac{2}{3}$ of the women did. Refer to the Math Nspired Statistics activity *Two-way Tables and Association* to decide whether men and women really have different opinions about whether equal pay for equal work is a problem.

Wrap Up

Upon completion of the lesson, the teacher should ensure that students are able to understand:

- The difference between probability of an outcome and the conditional probability of an outcome.
- How to interpret values in a two-way table.
- How to compute probabilities and conditional probabilities from graphs and tables.

Assessment

Identify each of the following as sometimes true, always true, or never true. Be prepared to justify your reasoning.

1. The probability of A given B is the same as the probability of B given A.

   Answer: Sometimes true. It is true if the number of outcomes for A and for B is the same number.

2. If the row and column totals of a two-way table with two rows and two columns are constant, knowing one of the cells is sufficient to complete all of the cells in the table.

   Answer: Always true.

3. Answer the questions below given the following conditions: the row and column totals remain constant; the entry in each cell is different.

	C	D	
A			35
B			42
	20	57	77

   a. The probability of A given C is 20/35.

      Answer: Never true. Given C means the denominator has to be 20.

   b. The probability of C given B will be the value in the cell for B and C (row B, column C) divided by 42.

      Answer: Always true.

TI-Nspire Navigator

Quick Poll can be used to assess student understanding. The questions above could be used to do this. Another approach is to display a two-way table or bar graphs similar to the ones in the exercise and use Quick Poll to collect students' responses to probability questions.

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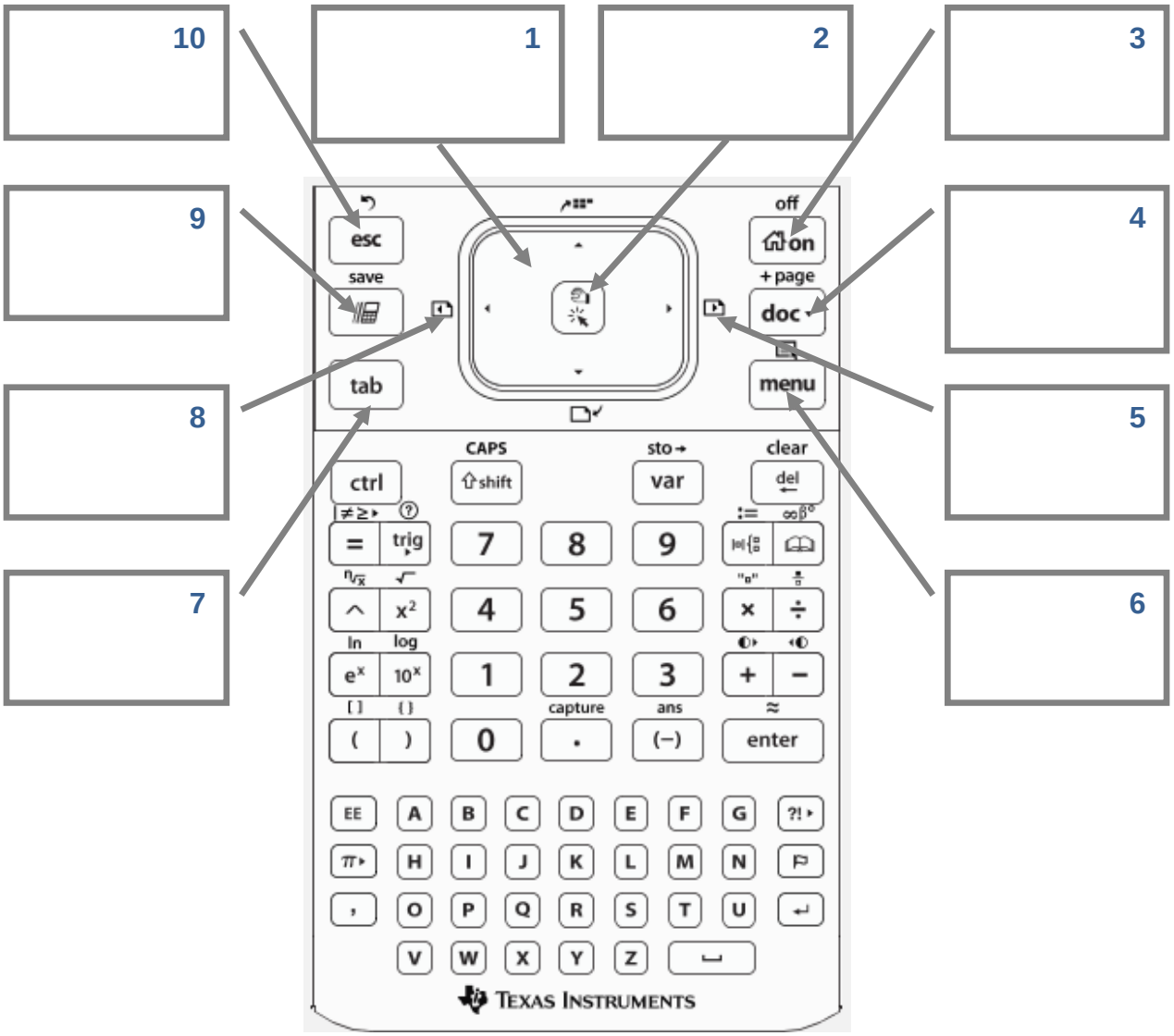
TI-Nspire™ CX Family Overview

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity you will become familiar with the most commonly used keys on the TI-Nspire™ CX family of handhelds.



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Getting Started with the TI-Nspire™ Teacher Software

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will explore basic features of the TI-Nspire™ Teacher Software. You will explore the Welcome Screen, add pages with Calculator and Graphs applications, and explore the menus and submenus of each application. You will explore the five tabs within the Documents Toolbox, as well as the options available in the Documents toolbar and the Status bar.

Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software

Step 1:

Open the Teacher Software. The Welcome Screen displays an icon for each of the eight applications: Calculator, Graphs, Geometry, Lists & Spreadsheet, Data & Statistics, Notes, Vernier DataQuest™, and Question. To see a brief description of each application, hover the cursor over each icon.

The Welcome Screen also allows you to view content, manage handhelds, transfer documents, and open documents. To see a description of each option, hover the cursor over each icon. To view the Welcome Screen at any time, go to **Help > Welcome Screen**.

A new TI-Nspire™ document may be opened by clicking any of the applications on the Welcome Screen. Alternatively, a new document may be opened by going to **File** and selecting **New TI-Nspire™ Document – Handheld Page Size** or **New TI-Nspire™ Document – Computer Page Size.**

- The **Handheld Page Size** allows documents to be viewed on all platforms. The content will be scaled when viewed on a tablet or larger screen.
- In **Computer Page Size**, content will not be scaled when viewed on smaller platforms and all content may not be visible on a handheld device.

Step 2:

Go to **File > New TI-Nspire™ Document – Handheld Page Size.** Select **1:Add Calculator**.

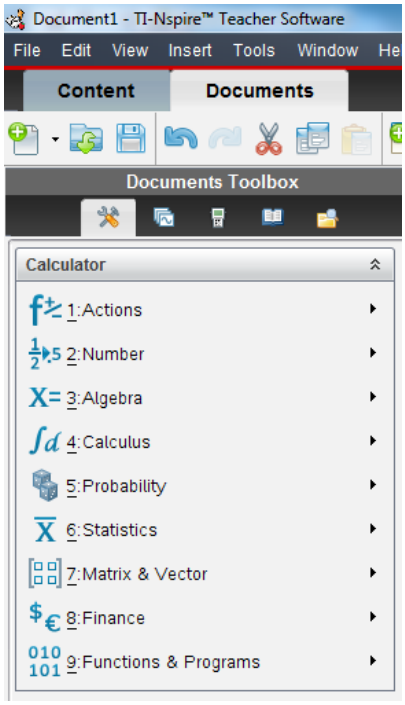
Step 3:

The Calculator application allows you to enter and evaluate mathematical expressions as well as create functions and programs.

In most cases, each application has a unique menu of commands and tools. To view the Calculator menu, go to the Documents Toolbox and select the **Document Tools** tab. Each item in the Calculator menu has a submenu.

Explore the various menus and submenus by entering and evaluating your own expressions.

Note: To access the Calculator menu on the handheld, press menu.

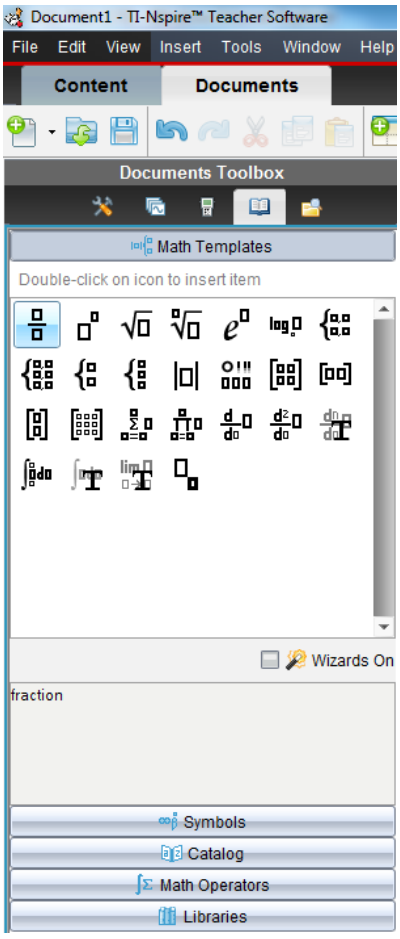


Step 4:

The **Utilities** tab contains Math Templates, Symbols, Catalog, Math Operators, and Libraries panes. Only one pane is displayed at a time, and the Math Templates pane is the default pane. Explore each of the other panes by clicking them.

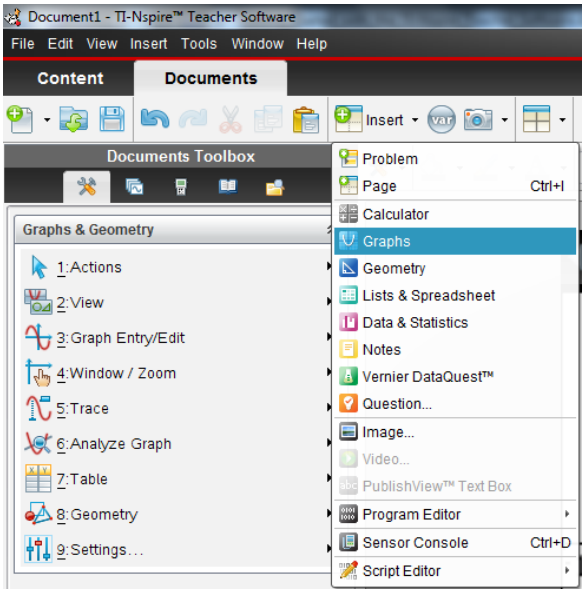
To insert a Math Template into the Calculator application, double-click it. Explore various Math Templates by evaluating your own expressions involving fractions, exponents, square roots, logarithms, and absolute value expressions.

Note: When evaluating expressions, the Calculator application displays rational expressions by default. To display a decimal approximation on a PC, press **CTRL + Enter**. To display a decimal approximation on a Mac, press **Command + Enter**.



Step 5:

The **Insert** menu allows you to insert problems and pages, along with each of the eight applications. A problem can contain multiple pages, and variables that are linked within a problem are linked across pages.

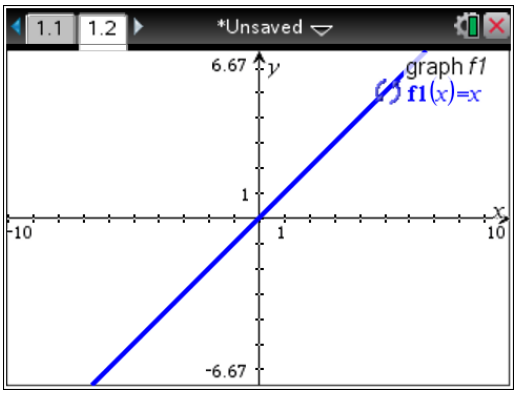


Insert a Graphs application by selecting **Insert > Graphs**.

The Graphs application allows you to graph and analyze relations and functions. Explore the various menus and submenus available in the Graphs application.

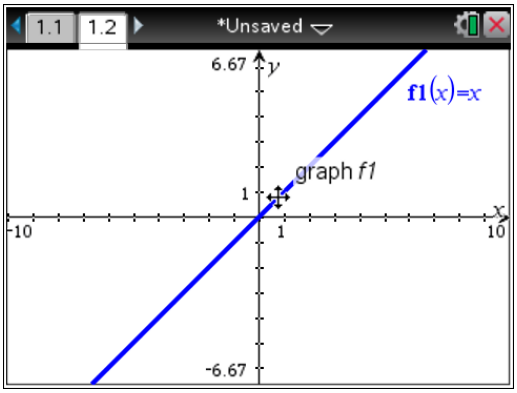
Step 6:

Graph the function ***f***(*x*) = *x* by typing ***x*** into the function entry line and pressing **Enter**.



Rotate the line by hovering the cursor over the upper-right or lower-left corner of the graph. When the rotational cursor, ↻, appears, rotate the line by clicking and dragging it.

Translate the line by hovering the cursor over the line near the y-intercept of the graph. When the translational cursor, ✣, appears, translate the line up or down by clicking and dragging it.

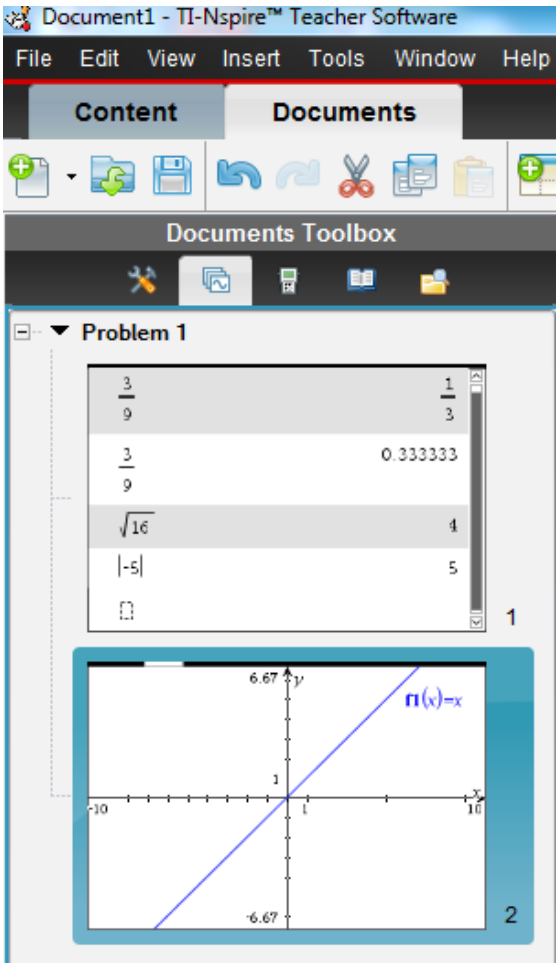


Step 7:

Since you have inserted a Calculator application and a Graphs application, your TI-Nspire™ document now has two pages. The Page Sorter view allows you to view thumbnail images of all pages in the current TI-Nspire document.

Access the Page Sorter by going to the Documents Toolbox and clicking the **Page Sorter** tab. Pages can be rearranged by grabbing and moving them. Right-clicking allows for pages to be cut, copied, and pasted.

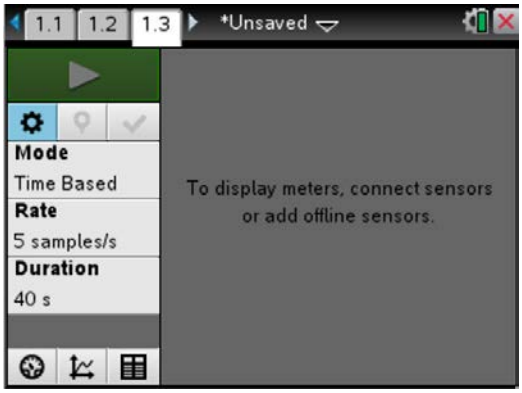
Note: To access Page Sorter in the handheld, press ctrl ▲. To right-click in the handheld, press ctrl menu.



Step 8:

The Vernier DataQuest™ app can be used to collect, view, and analyze real-world data. Insert a page with the Vernier DataQuest app by selecting **Insert > Vernier DataQuest™**.

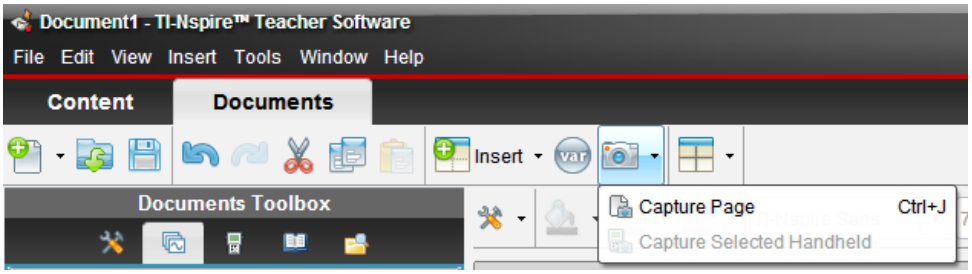
Though no data will be collected during this activity, the data meter will automatically launch when a Vernier sensor is connected to the computer's USB port.



Step 9:

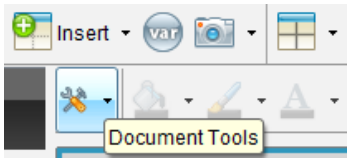
The Documents toolbar allows you to create, open, and save a TI-Nspire document. Commands such as Undo, Redo, Cut, Copy, and Paste are also available. Explore these options by hovering the cursor over each icon. Pages, problems, and applications can be inserted and variables can be stored.

Take a Screen Capture of the current page by selecting **Take Screen Capture > Capture Page**. This Screen Capture can be saved as an image.



Page layouts allow multiple applications to appear on one screen. Explore the various page layouts that are available by clicking **Page Layout**.

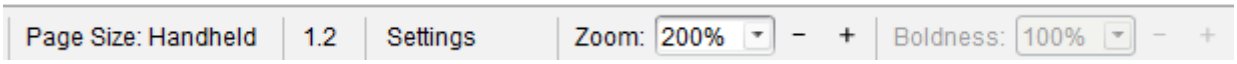
The Document Tools menu contains tools and commands for the current application.



To change the fill color, line color, or text color, select an object and then select a color from the appropriate menu. To receive additional information about a given menu, hover the cursor over it. Not all color menus are available on all applications.

Step 10:

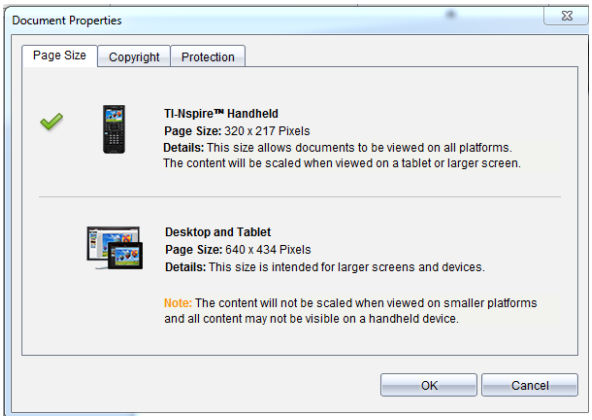
The Status Bar allows the user to access Document Properties, Settings, and to adjust the zoom of the SideScreen.



Increase the zoom of the SideScreen to 200% by selecting *200%* in the Zoom menu. The Boldness feature is enabled when using a PublishView™ document.

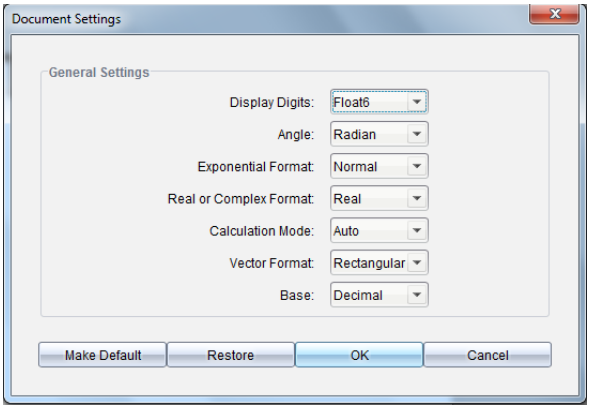
Step 11:

View the Document Properties by going to **File > Document Properties**. The Document Properties also can be viewed by going to the Status Bar and double-clicking **Page Size: Handheld** or **Page Size: Computer**. The page size displayed depends upon the type of TI-Nspire document originally opened.



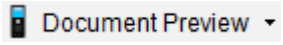
Step 12:

View the Document Settings by going to **File > Settings > Document Settings**. The Document Settings can also be viewed by going to the Status Bar and double-clicking **Settings**.



Note: To move across fields in the Document Settings window, press TAB. To change the setting in a given field, press the down arrow, select the desired setting, and press TAB to move to the next field. To exit the window, press ENTER.

Step 13:

Preview the document in Handheld or Computer view by clicking 

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Step 14:

To access the TI-SmartView™ emulator for TI-Nspire, go to the Documents Toolbox and select the **TI-SmartView** tab.

TI-SmartView emulator has three available views: Handheld only, Keypad + SideScreen, and Handheld + Side Screen. Explore each of these views.

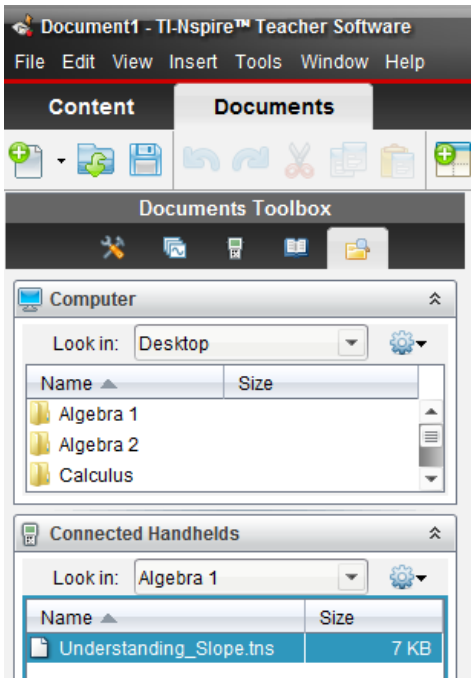
The TI-SmartView emulator has three available keypads:

- TI-Nspire™ CX
- TI-Nspire™ with Touchpad
- TI-Nspire™ with Clickpad

Each keypad has three available views: Normal, High Contrast, and Outline. Click the **Keypad Options** menu and explore each keypad and view.

Step 15:

Documents can be transferred between the computer and connected handhelds using the Content Explorer in the Documents Workspace. Explore the Content Explorer by clicking the **Content Explorer** tab.



To transfer a TI-Nspire document from the computer to the connected handheld, locate the document in the Computer panel. Click, drag, and drop it into the desired handheld or folder in the Connected Handhelds panel.

To transfer a TI-Nspire document from the connected handheld to the computer, locate the document in the Connected Handhelds panel. Click, drag, and drop it into the desired folder in the Computer panel.

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The Content Workspace

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will explore the Content Workspace of the TI-Nspire™ Teacher Software. You will browse web content, manage computer content, and transfer a document to a connected handheld.

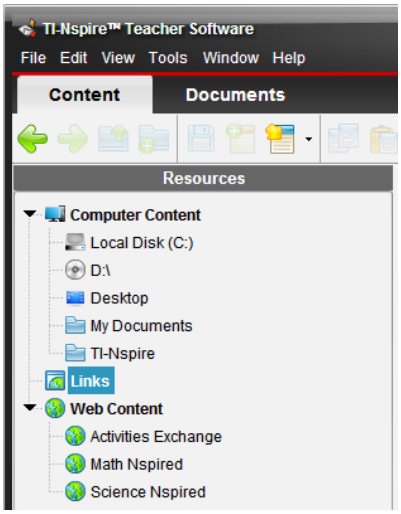
Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software with internet connection
- TI-Nspire™ handheld and standard-A to mini-B USB cable

Computer Content, Links, and Web Content

Step 1:

Open the Teacher Software. If the Welcome Screen appears when the software is opened, go to the Content Workspace by clicking View Content. Otherwise, go to the Content Workspace by clicking the **Content** tab.



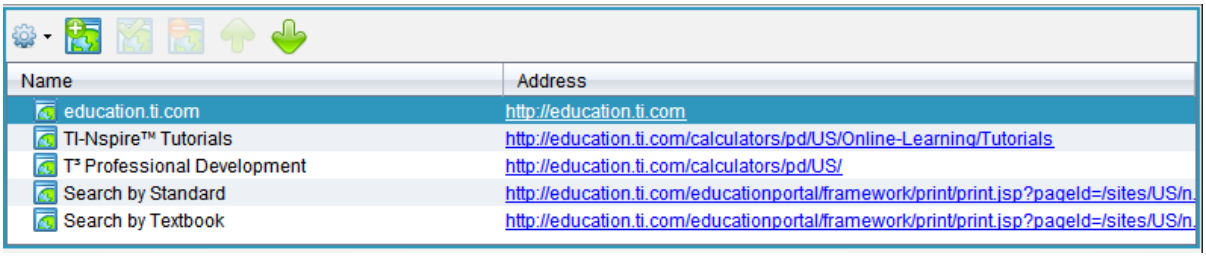
Step 2:

The Resources panel contains three types of resources: Computer Content, Links, and Web Content. If a handheld is connected to the computer, a fourth resource, Connected Handhelds, appears. Select Links.

Note: Each resource can be collapsed by clicking ▼ and expanded by clicking ▶.

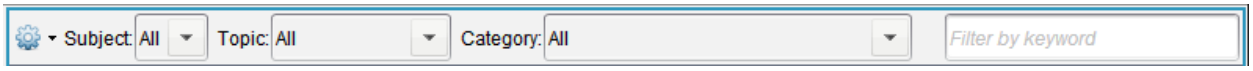
Step 3:

The Content Workspace offers access to online resources through links to various websites. A list of links appears in the Content window**.** When a link is clicked, a Web browser is launched. Links can be added, edited, and removed by clicking the **Add Link**, **Edit Link**, and **Remove Link** icons.



Step 4:

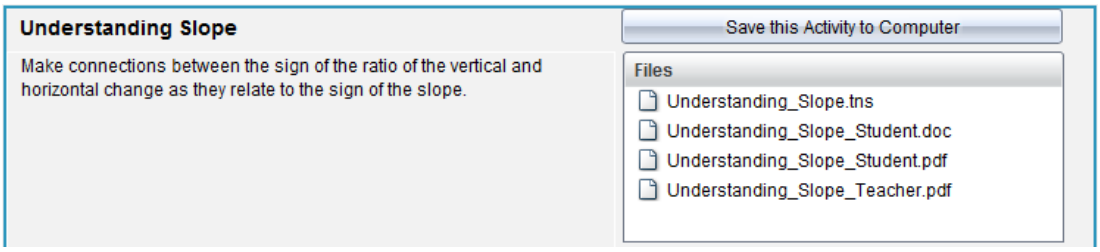
The Content Workspace offers the ability to search for lessons available online at Math Nspired or Science Nspired. In the Resources panel, go to Web Content and select **Math Nspired** or **Science Nspired**. The Content pane toolbar contains cascading fields for Subject, Topic, and Category. Activities can also be located using the **Filter by keyword** field.



Step 5:

Once a lesson is located, details about the activity appear in the Preview pane. The activity might appear as a lesson bundle, which consists of multiple files and can contain multiple file types. If the activity is a lesson bundle, the Files window appears and lists the individual files in the lesson bundle.

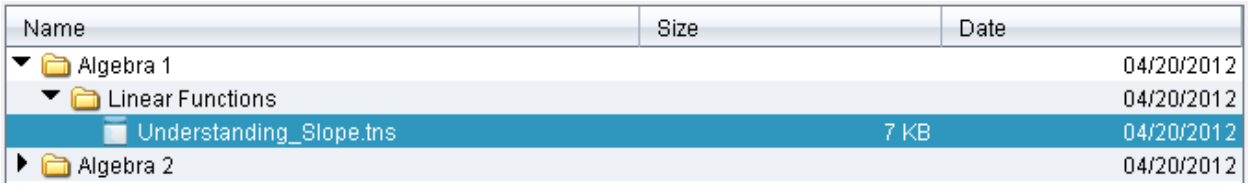
Save the lesson bundle to your Desktop by clicking **Save this Activity to Computer**. To save an individual file, right-click it and select **Save to Computer**.



Step 6:

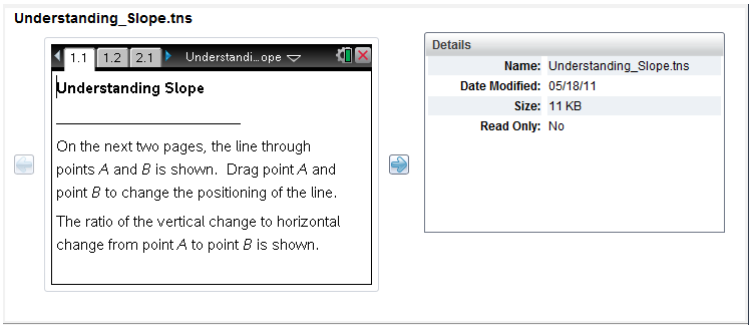
In the Resources panel, go to Computer Content**.** Here, you have the ability to view the documents and folders available on the Desktop, in the My Documents folder, and in the TI-Nspire folder.

The Content pane toolbar provides tools needed to locate folders and files. The **Look in** field contains the path of the current folder or file. To move up a level in the folder hierarchy, click  . To create a new folder, click  . To search for a document containing a specific word, use the keyword field.



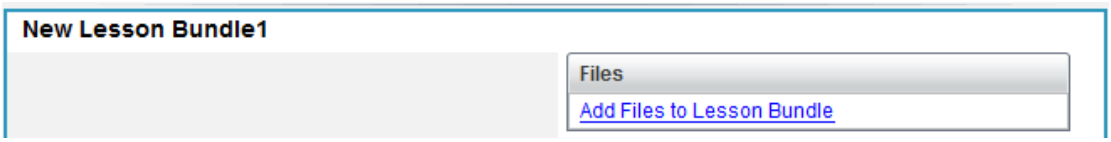
Step 7:

When a TI-Nspire™ document is selected, the first page of the document appears in the Preview pane. If the document has multiple pages, the forward arrow can be used to preview additional pages. To open a TI-Nspire document in the Teacher Software, double-click it.



Step 8:

To create a lesson bundle, click the **Create a New Lesson Bundle** icon on the Content Workspace toolbar. Click **Add Files to Lesson Bundle** and a dialogue box appears that allows you to browse local content. Select a file and click **Add**. Once a TI-Nspire document is added to the lesson bundle, click the name of the document and the first page appears in the preview pane.

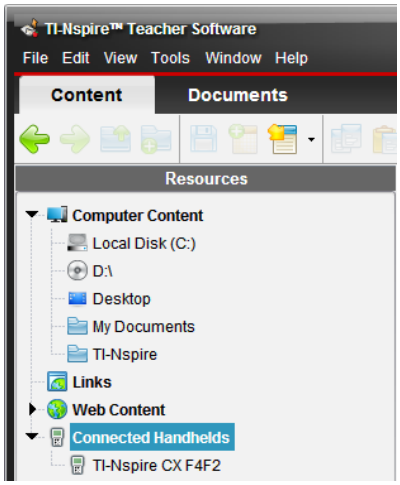


Transferring Documents to Connected Handhelds

Step 9:

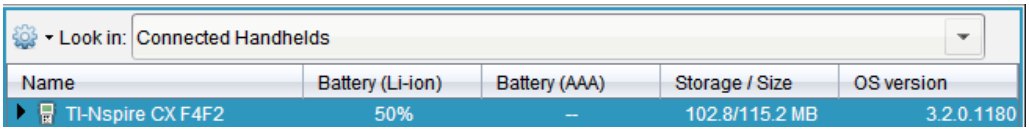
Connect a TI-Nspire™ handheld to the computer using the USB connection cable. In the Resources panel, click **Connected Handhelds**.

Note: Multiple handhelds can be connected to the computer using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected to the computer, then multiple handhelds appear in the list of Connected Handhelds.



Step 10:

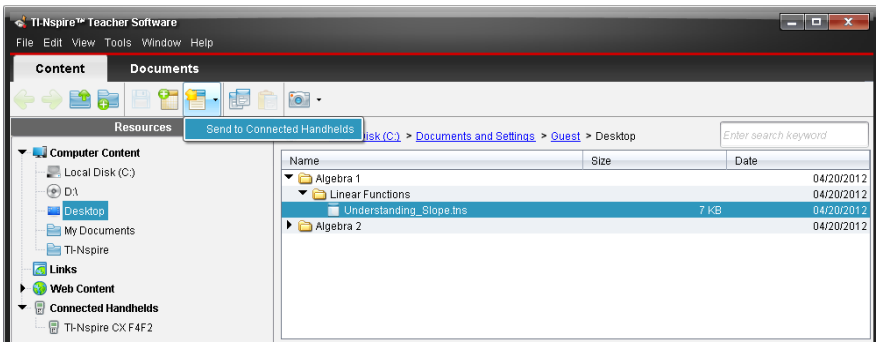
The connected handheld appears in the Content window, along with battery, storage, and OS information. To view the documents on a connected handheld, right-click it and select Open. The handheld can also be renamed, its screen can be captured, and the OS can be checked and updated.



Step 11:

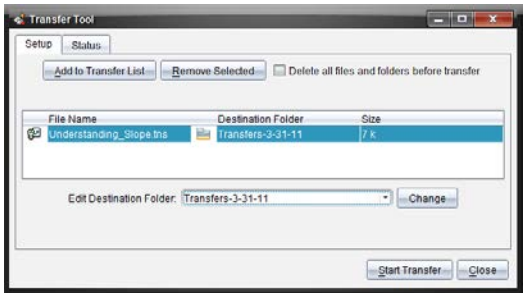
Locate a TI-Nspire document on your computer by browsing Computer Content in the Resources panel. Send the document by dragging and dropping it to the connected handheld. The document can also be sent by right-clicking the document name and selecting **Send to Connected Handhelds**.

Note: When sending multiple documents, locate the first document in the Content Window and select  **Send to Connected Handhelds**.



Step 12:

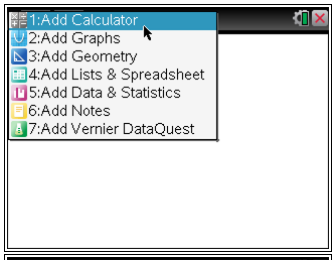
Upon selecting **Send to Connected Handhelds**, the Transfer Tool window appears. To add an additional document, select **Add to Transfer List** and locate the additional document. To remove a document, select the document and click **Remove Selected**.

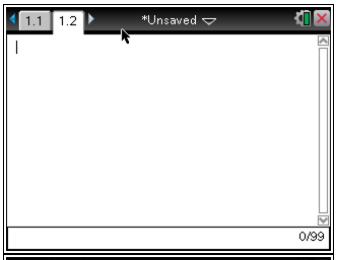


To change the destination folder, select the document and go to the Edit Destination Folder field. To identify an existing folder, select it from the drop-down menu and click Change. To create a new folder, type its name into the field and click Change. To send the document to the handheld, click **Start Transfer**. Once the Status tab indicates that the transfer is complete, click **Stop Transfer**.

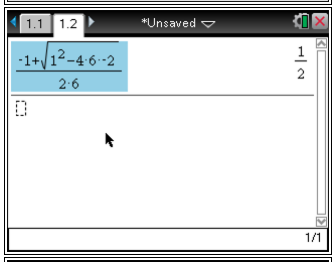
Converting Fractions to Decimals

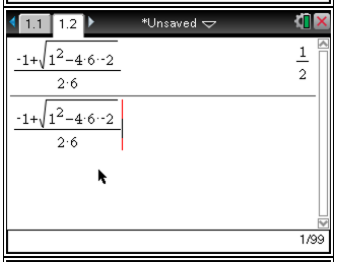
Insert a Calculator page:
Press [ctrl] [I] and choose **Add Calculator**.



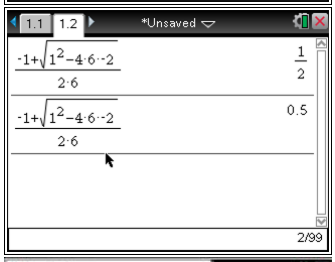


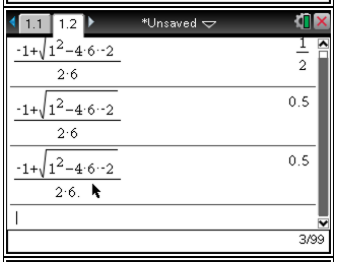
Use the quadratic formula to solve $\mathbf{f}(x) = 6x^2 + x - 2$ on the Calculator page. TI-Nspire™ defaults to a fraction result. Copy and paste the expression by using the up arrow on the Touchpad (▲) to highlight, then press [enter].



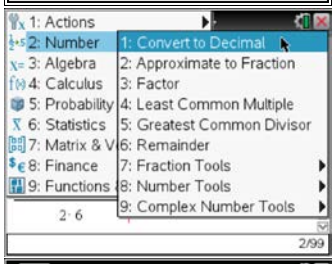


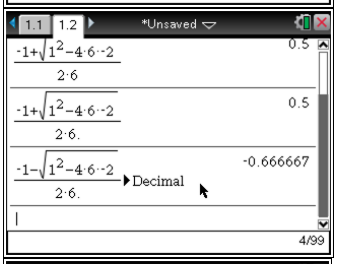
Method 1: Do you see the small [≈] (approximate) symbol above the [enter] key? Activate the **Approximate** command by pressing [ctrl] [enter].
Method 2: Insert a decimal point [.] in the expression.



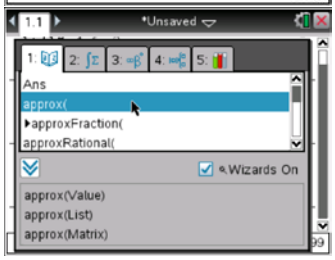


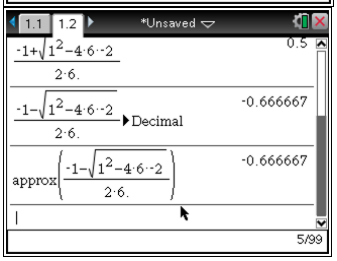
Copy and paste the expression and edit the expression to find the other root.
Method 3: Position the cursor after the expression and press **Menu > Number > Convert to Decimal**.



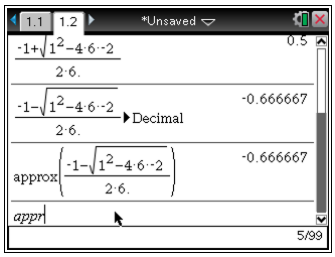


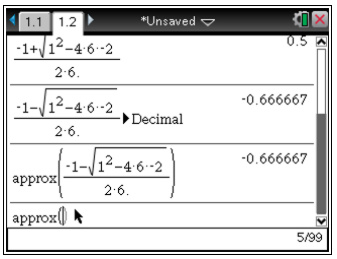
Method 4: Find the **Approximate** command in the Catalog. Press [📖], then press [A] to locate the commands that begin with A (make sure you are in tab 1). Use the Touchpad arrows to locate the command, press [enter] to choose **approx(**, then copy and paste the expression.





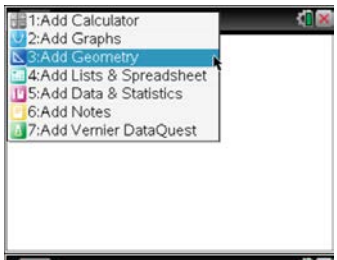
Method 5: Type **approx(** using the alpha letters on the keypad ([A][P][P][R][O][X][(]), then copy and paste the expression. Notice the letters are in italics until the full command has been entered.

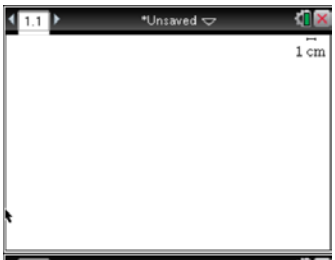


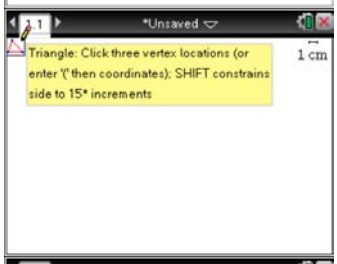


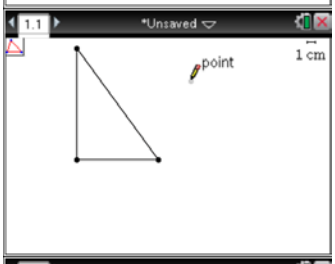
Grabbing and Moving a Point

Insert a Geometry page:
Press ctrl I and choose **Add Geometry**.
To construct a triangle, press **Menu > Shapes > Triangle**.
Hover over the **Triangle** icon in the upper left corner to read the **Tool Tip**.
Click ( ) in three locations on the screen to construct the triangle.
Press esc to exit the **Triangle** tool.

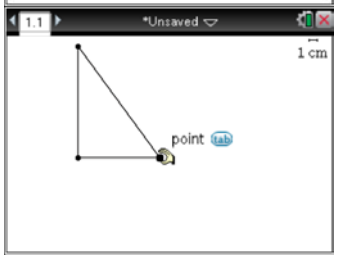


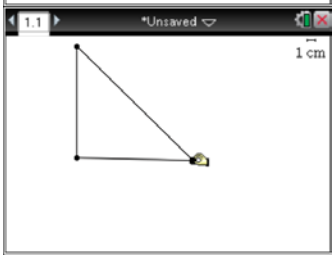


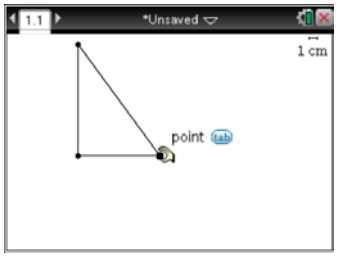


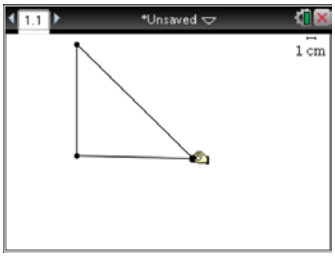


Grab a point using **Method 1**:
Hover over the point until you see the word **point** appear. Press and hold for one second. The hand becomes closed over the point. Move the Touchpad as desired to move the point. Press esc to drop the point at the desired location.
Hover over the point until you see the word **point** appear. Press tab if you want to use the object underneath the point (in this case, the triangle).



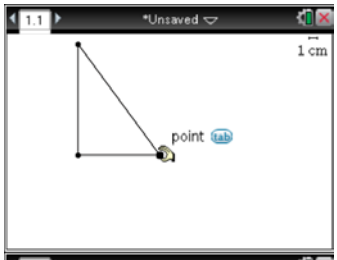


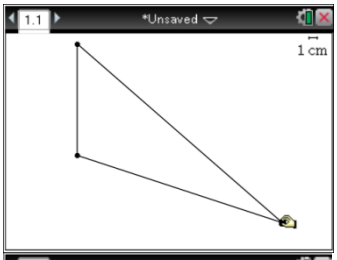


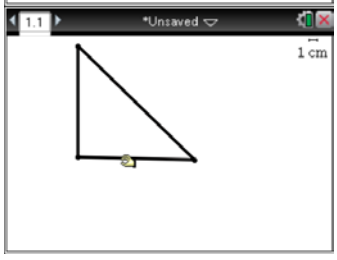


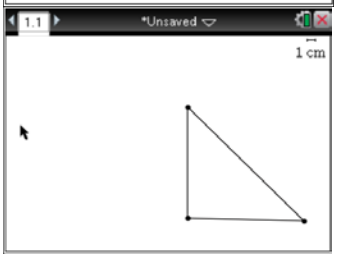
Grab a point using **Method 2**:
Press ctrl to close the hand and grab the point.
Once the point is grabbed, you can move the point by using the arrow keys ◀▶▲▼ on the Touchpad. Alternatively, you can swipe your finger across the Touchpad to move the point more quickly.
Press esc to let go of the point.

Try moving the whole triangle by grabbing one of its sides.



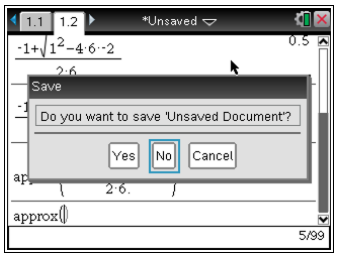


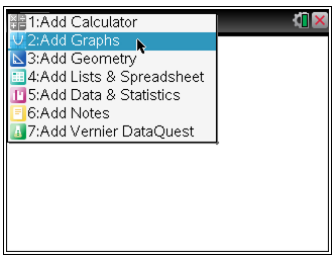




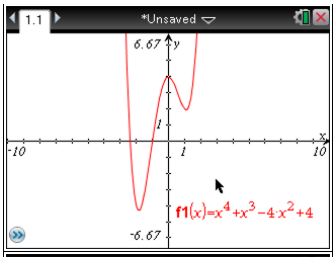
Finding Points of Interest

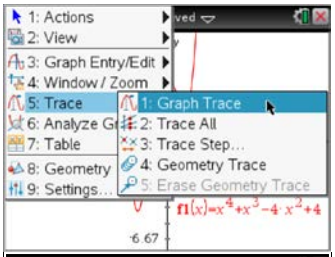
Start a New Document:
Press [on] and choose **New Document**. You are prompted with the question, "Do you want to save?" Say No by pressing [tab] to advance to the next field; then press [enter] or [ctrl] to make the selection. Choose **Add Graphs**.
Graph the function $f1(x) = x^4 + x^3 - 4x^2 + 4$.

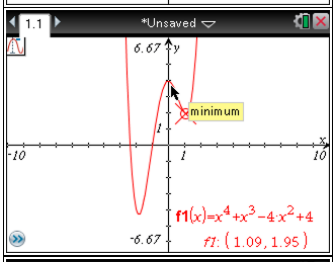


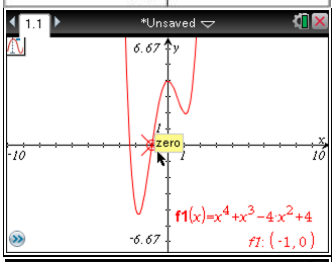


Method 1: Open the **Trace** tool by pressing **Menu > Trace > Graph Trace**.
Use the ◀▶ arrows on the Touchpad to find the local minimum, maximum, and zeros of the function. It is common for new users to try (unsuccessfully) to use the ▲▼ keys to operate the **Trace** tool. Only use the left and right arrow keys!

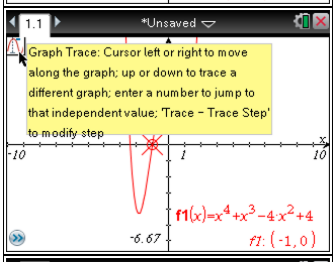


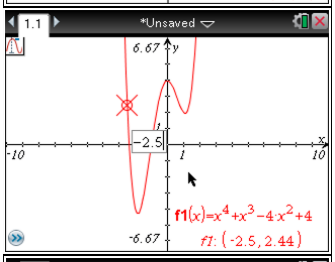




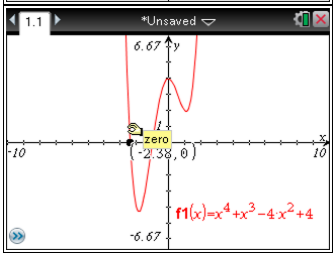


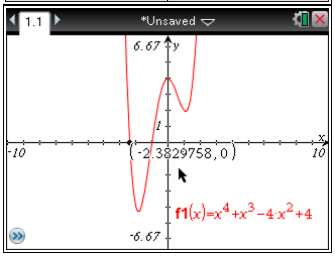
Hover over the **Graph Trace** icon in the top left corner of the screen. The **Tool Tip** explains how to use the tool.
While in **Trace** mode, type a number to "jump" to that value of x on the graph.



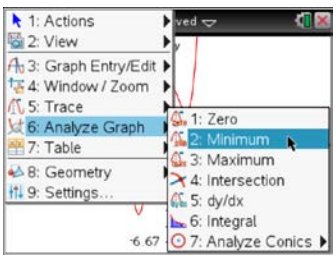


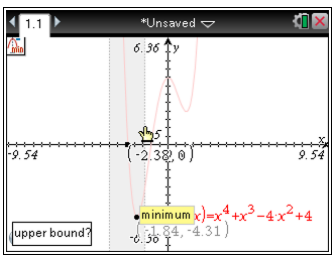
Method 2: While the **Trace** tool is open, drop a point on the graph by pressing [enter]. Grab ([ctrl] [ctrl]) and move the point to locate the zero.
Hover over the x-coordinate of the point and press [+] or [−] repeatedly to see more (or fewer) decimal places displayed.





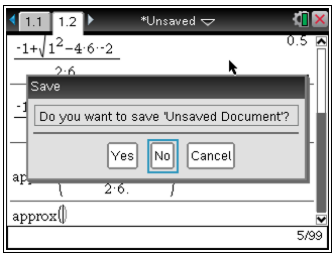
Method 3: Open the **Analyze** tool by pressing **Menu > Analyze Graph > Minimum**.
Click ([ctrl]) to mark the lower bound of the search region, use the Touchpad arrows (◀▶) to move, and press [enter] to identify the interval in which to display the minimum.

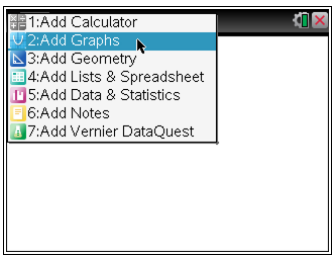




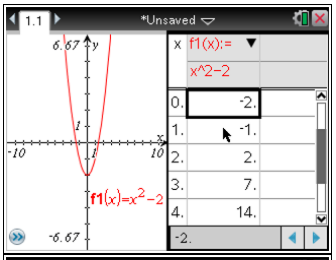
Using a Table

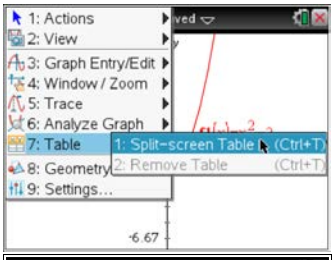
Start a New Document:
Press [on] and choose **New Document**. You are prompted with the question, "**Do you want to save?**" Say **No** by pressing [tab] to advance to the next field; then press [enter] or [ ] to make the selection. Choose **Add Graphs**.



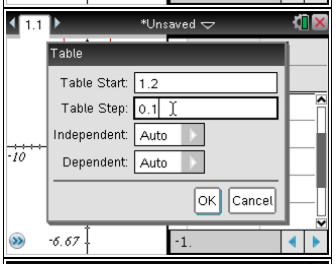


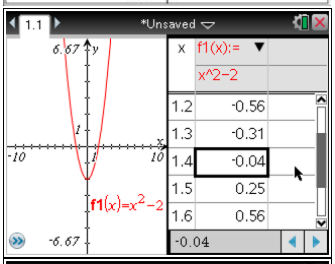
Graph the function $f1(x) = x^2 - 2$.
Method 1: Press [ctrl] [T] to insert a table.
Method 2: Press **Menu > Table > Split-screen Table**.



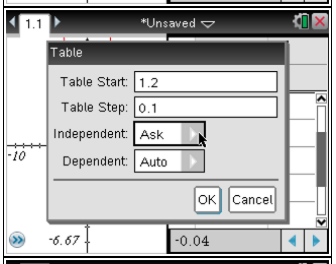


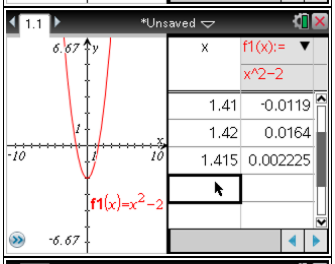
To edit the table settings, press **Menu > Table > Edit Table Settings**. Change the Table Start to **1.2** and the Table Step to **0.1** to find the roots of the function numerically.



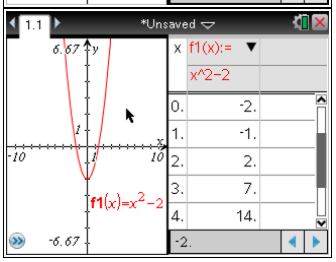


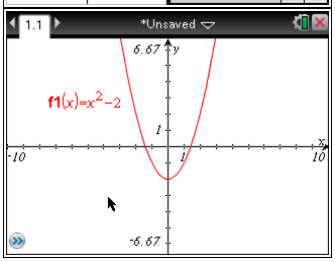
Change the table settings so that you can type in any *x*-value you wish.
Press **Menu > Table > Edit Table Settings**. Change the Independent variable to **Ask**.



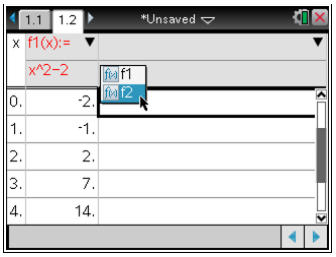


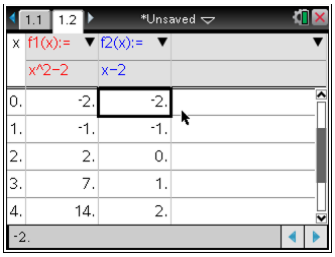
Press [ctrl] [T] to remove the table.





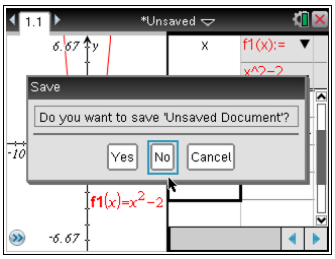
Graph the function $f2(x) = x - 2$.
Press [ctrl] [I] and add a Lists & Spreadsheet page. To see the table for **multiple functions**, press [ctrl] [T], choose the function, and then press ▶ to navigate to the next column and choose another function.

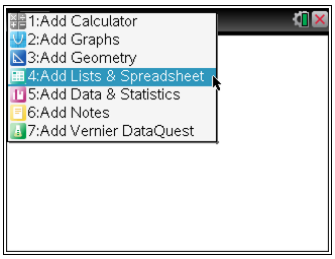


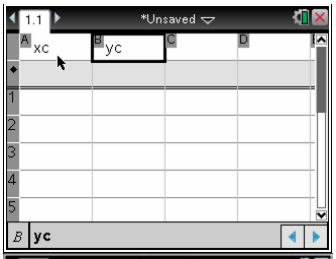


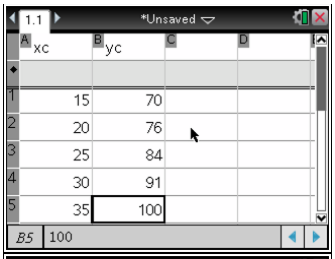
Graphing a Scatter Plot

Start a New Document:
Press [on] and choose **New Document**. You are prompted with the question, "**Do you want to save?**" Say **No** by pressing [tab] to advance to the next field; press [enter] or [ ] to make the selection. Choose **Add Lists & Spreadsheet**.
You *must* name your lists (which many users forget to do).
Name the lists **xc** and **yc** (for *x* and *y*-coordinates). Enter {15,20,25,30,35} in list **xc** and {70,76,84,91,100} in list **yc**.

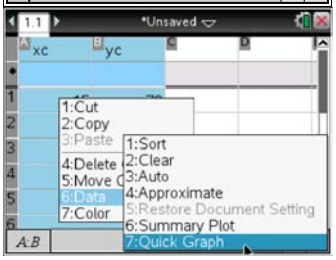


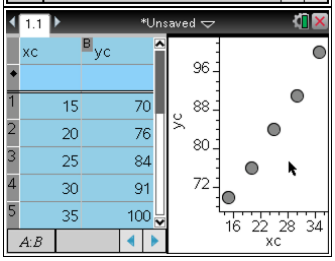




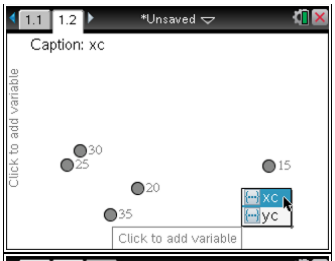


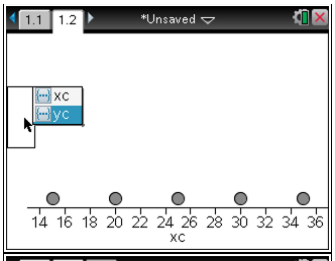
Method 1: To select both columns, move your cursor over the A at the top of the column and press [ ]. Then hold [shift] and press ▶ to highlight column B as well. (Alternatively, press ▲ until column A is highlighted, then hold [shift] and press ▶ to highlight column B.) Right-click ([ctrl] [menu]) and choose **Data > Quick Graph**.



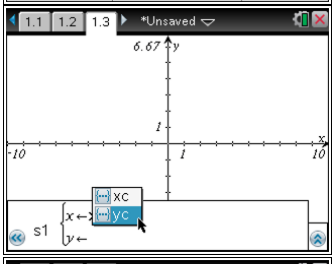


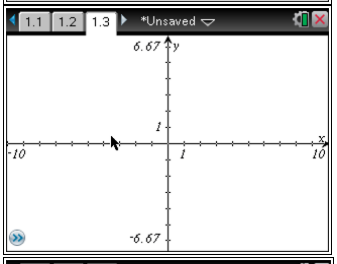
Method 2: Press [doc] **> Insert > Data & Statistics**. Click ([ ]) near the bottom of the screen, where it says "**Click to add variable**," and choose **xc**. Move your cursor to the left side of the screen, click ([ ]), and choose **yc**.



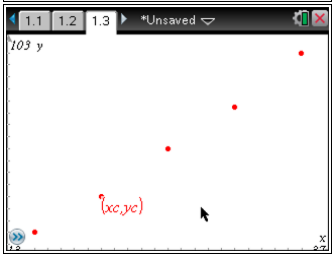


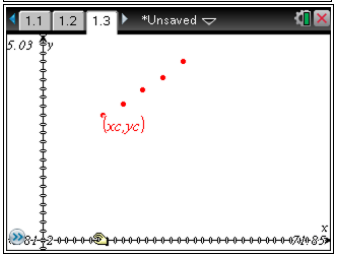
Method 3: Press [ctrl] [I] and choose **Add Graphs**. Press **Menu > Graph Entry/Edit > Scatter Plot**.
Press [var] and choose **xc** for the *x* list and **yc** for the *y* list. Press [enter] to graph the scatter plot.





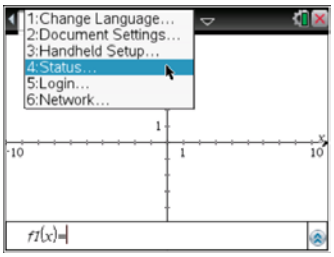
What? You can't see your graph?
Press **Menu > Window/Zoom > Zoom Data**.
Since a Graphs page does not automatically keep the axes in view, you may want to grab the axes and move toward the origin to zoom out.

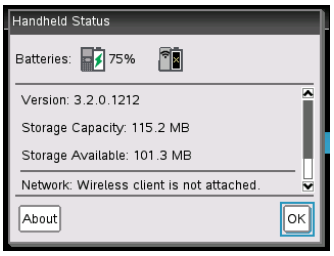




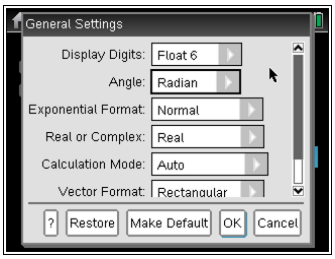
Adjusting the Settings

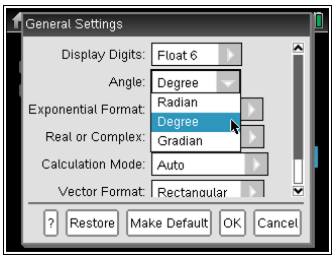
One way to access the settings is to click ( ) on the battery/tool icon in the top-right corner of the screen. Choosing **Status** shows a screen containing the version of your operating system, as well as information about your battery life and available memory.



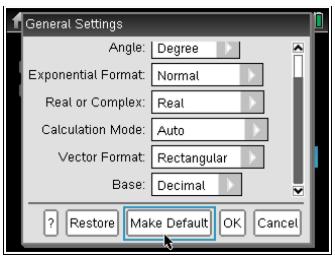


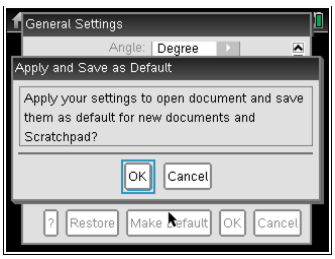
Another way to access the settings is to press **on** **> Settings**. To change the Calculator settings, choose **Document Settings**. Use the **tab** key to navigate to the next field (like a computer). Click ( ) or press ▶ to make a change to one of the settings.



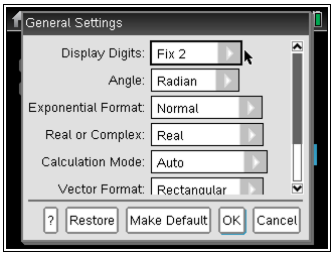


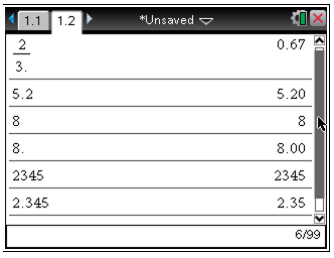
Warning! If you click the **OK** button, the settings of your **Scratchpad** will *not* change! However, if you **tab** down to **Make Default**, you will receive a prompt asking if you want to apply the setting changes to the **Scratchpad**. Click **OK** to do so.



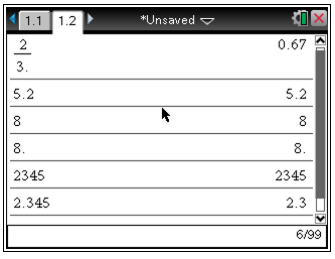


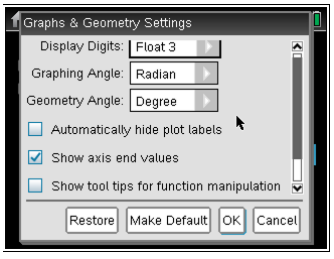
Sometimes there is some confusion about the **Display Digits** setting. The **Fix 2** command will automatically show two decimal places of any expression with a decimal. Use this setting when you are working with money problems and want to include cents in the result.





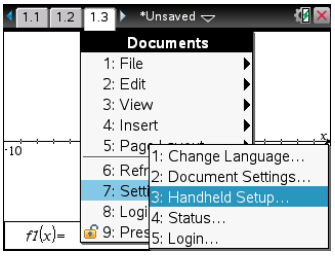
In contrast, the **Float 2** command will show at most two digits of any expression that contains a decimal.

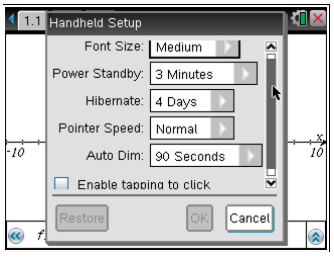




Insert a Graphs (or Geometry) page and press **Menu > Settings** to access the settings for a Graphs or Geometry application.

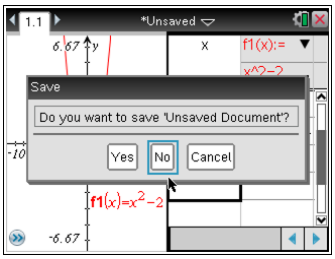
Press **doc** **> Settings & Status > Handheld Setup**. You can also click ( ) the triangle next to the document name at the top of the page to open the **Documents** menu. Use the **Handheld Setup** menu to change the font size and adjust the power settings of your handheld.

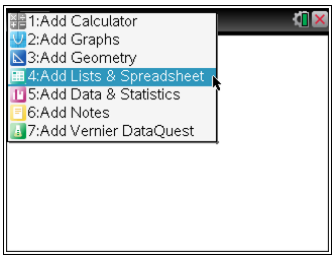




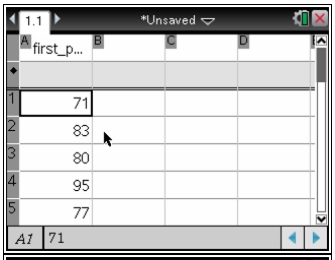
Graphical Representations of Data

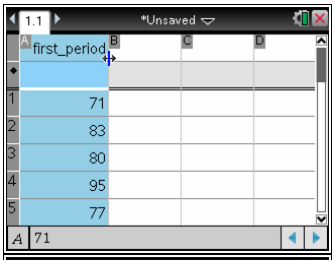
Start a New Document:
Press [on] and choose **New Document**. You are prompted with the question, "**Do you want to save?**" Say **No** by pressing [tab] to advance to the next field and then [enter] or [ctrl] to make the selection. Choose **Add Lists & Spreadsheet**.



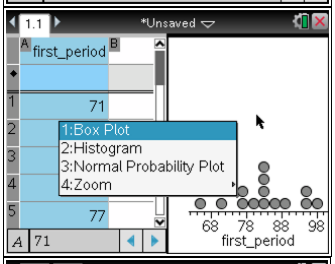


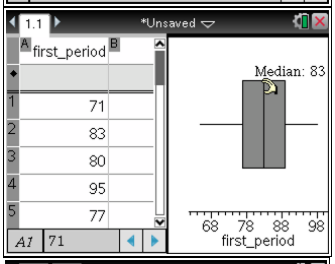
Name column A **first_period**. Populate the list with the following test scores: {71, 83, 80, 95, 77, 98, 65, 86, 77, 83, 83, 89, 95, 72, 83}. **Resize** the column by grabbing near the top of the screen in between columns A and B (look for the ⇹ symbol).



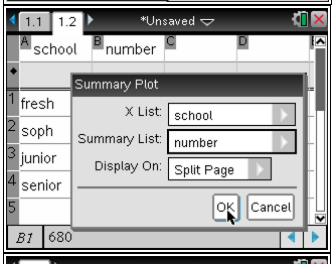


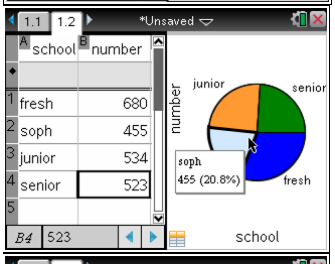
Press **Menu > Data > Quick Graph** to create a dot plot of the data.
Right-click ([ctrl] [menu]) and choose **Box Plot** (or **Histogram** if you prefer).
Press [ctrl] [I] and **Add Lists & Spreadsheet**.



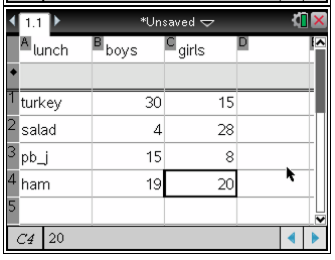


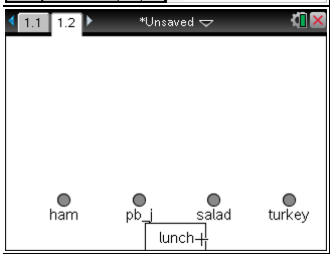
Title the first list **school** {fresh, soph, junior, senior} and title the second list **number** {680, 455, 534, 523}. Press **Menu > Data > Summary Plot** and configure the dialog box as shown. Right-click ([ctrl] [menu]) and choose **Pie Chart**.



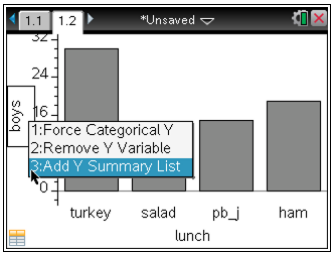


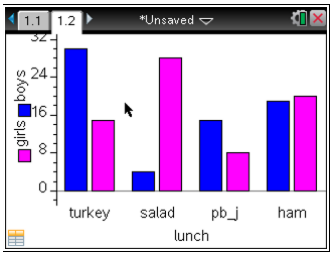
Press [ctrl] [I] and **Add Lists & Spreadsheet**.
Title the first list **lunch** {turkey, salad, pb_j, ham}. Title the second list **boys** {30, 4, 15, 19}. Title the third list **girls** {15, 28, 8, 20}. Press [ctrl] [I] and **Add Data & Statistics**. Click near the bottom of the page and choose **lunch**.





Choose **Add Y Summary List** by right-clicking ([ctrl] [menu]) in the box on the left, and choose **boys**. Repeat (or press **Menu > Plot Properties > Add Y Summary List**) and choose **girls**. Change the color of the bars by right-clicking and choosing **Color > Fill Color**.





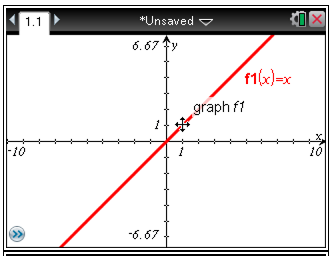
Determining a Line of Best Fit

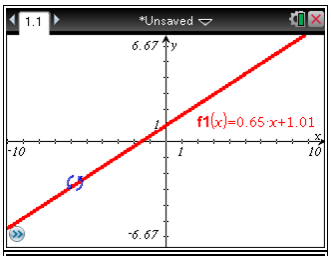
Start a New Document:
Press [on] **> New Document > Add Graphs**. Graph the function **f**(*x*) = *x*. Hover the cursor over the function until you see ✣ or ↻, and press [ctrl] [touchpad]. Use the Touchpad arrow keys to transform the function.

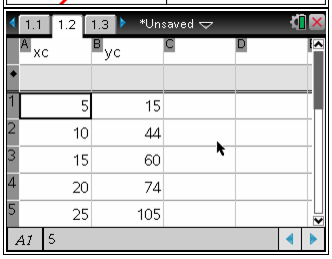
Press [ctrl] [I] and choose **Add Lists & Spreadsheet**. Title the first list **xc** {5, 10, 15, 20, 25}. Title the second list **yc** {15, 44, 60, 74, 105}. Press [doc] **> Insert > Data & Statistics**. Choose **xc** and **yc** in the boxes where it says "**Click to add variable**." Press **Menu > Analyze > Add Movable Line**.
If you grab ([ctrl] [touchpad]) the movable line near the center of the line, you can translate it horizontally or vertically. Grab near either end to change its slope.
Click on the movable line and press [del] to remove it. Press **Menu > Analyze > Regression > Show Linear(mx+b)**.
Press **Menu > Analyze > Residuals > Show Residual Squares**.
To show the residual plot, press **Menu > Analyze > Residuals > Plot Residuals**. **Note**: You cannot calculate a regression on a Graphs page.

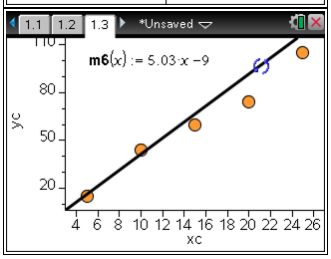
Press [ctrl] [I] and select **Add Calculator**. To perform a regression on a Calculator page, press **Menu > Statistics > Stat Calculations >Linear Regression(mx+b)**. Configure the dialog box as shown. Notice that the regression will be stored in **f2**.

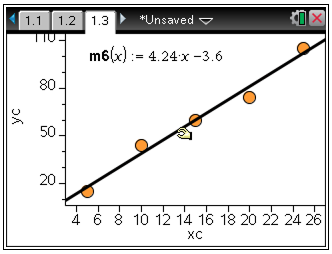
Press [ctrl] [I] and **Add Lists & Spreadsheet**. Press **Menu > Statistics > Stat Calculations > Linear Regression(mx+b)**. Press [ctrl] [I] and select **Add Notes**. Press [ctrl] [M] to open a Math Box. Press **Menu > Calculations > Statistics > Stat Calculations > Linear Regression(mx+b)**.

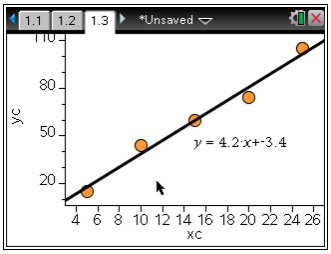


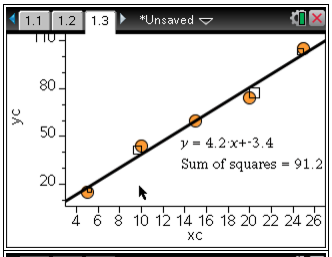


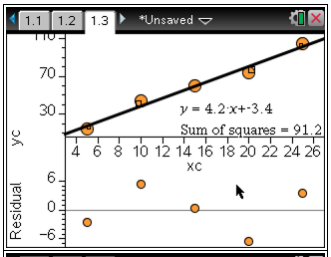


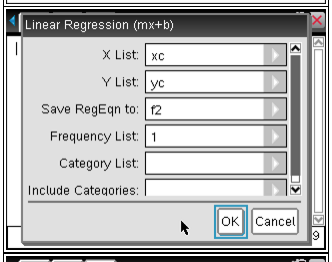


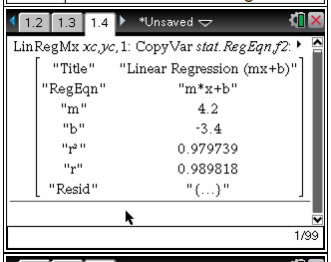


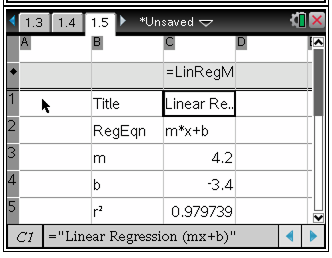


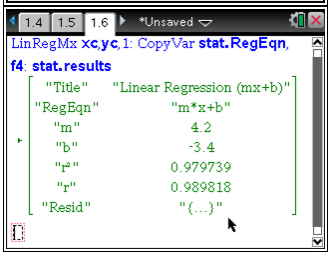






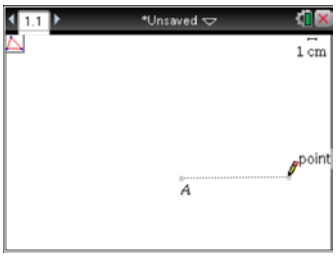


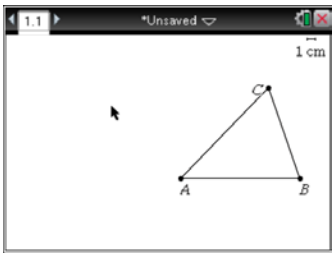




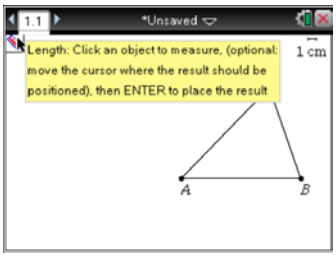
Working with Geometry Objects

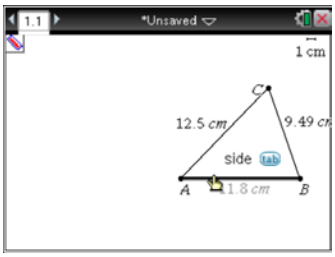
Insert a Geometry page:
Press ctrl I and choose **Add Geometry**. Press **Menu > Shapes > Triangle**. Click ( ) to drop a point then type A to label the first vertex of the triangle. Click to drop another point and type B, then click to drop a final point and press C.



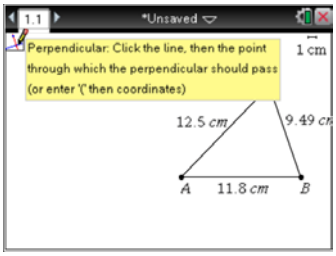


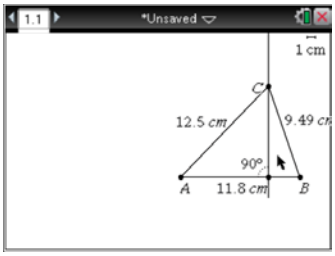
To measure the lengths of the sides, press **Menu > Measurement > Length**. Hover over the **Length** icon to see the **Tool Tip**. Hover over a side of the triangle, press tab until the word **side** appears, click once to measure, and click again to drop the measurement on the page.



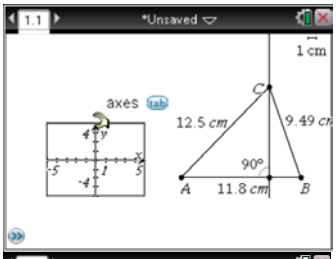


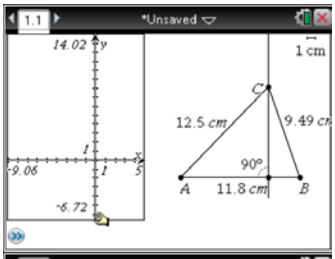
Construct an altitude in the triangle. Press **Menu > Construction > Perpendicular**. Click on point C and segment AB. Measure the right angle by pressing **Menu > Measurement > Angle**. Click the three points that form the angle, choosing the vertex second.



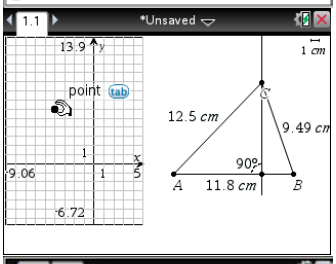


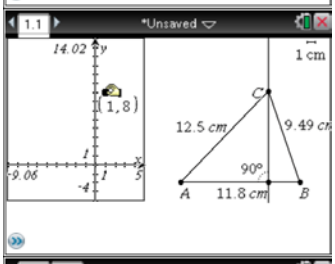
To insert an Analytic Window, press **Menu > View > Analytic Window**. Hover over the end of an axis and press tab until the word **axes** appears. Grab (ctrl) the end of the axis and use the Touchpad to resize the Analytic Window.



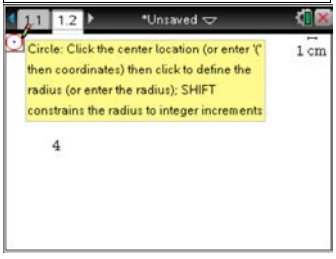


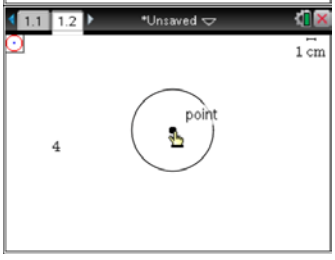
Show the grid by pressing **Menu > View > Grid > Lined Grid**. Place a point on the grid by pressing **Menu > Geometry > Points & Lines > Point On**. Click twice to drop a point on the grid. Hide the grid by pressing **Menu > View > Grid > No Grid**.





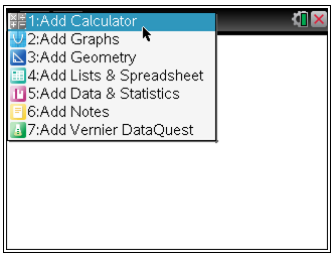
To insert a Geometry page, press ctrl I and choose **Add Geometry**. Construct a circle with radius 4. First, right-click (ctrl menu), choose **Text**, type **4**, and then press enter. Press **Menu > Shapes > Circle**. Click on the **4**, then click again to place the circle.

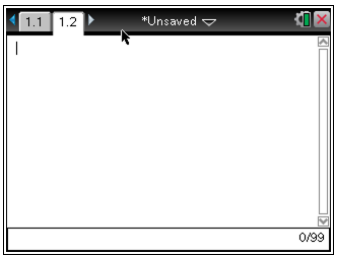




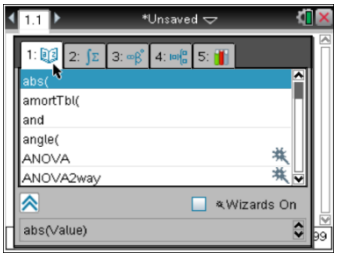
Using the Catalog

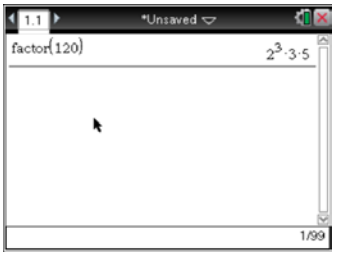
Insert a Calculator page:
Press ctrl I and choose **Add Calculator**.



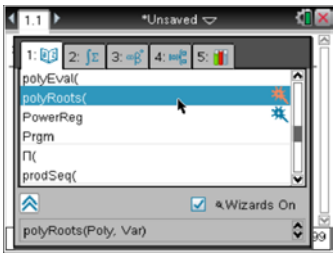


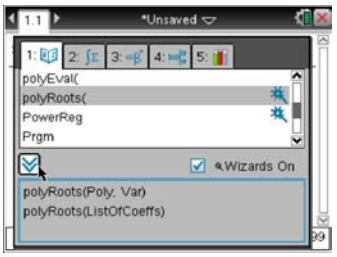
Press 📖 to open the **Catalog**. Press 1 to access the commands. If you want to use the **Factor** command, press F to jump to the commands that begin with the letter F. Press enter to select the command that is highlighted.



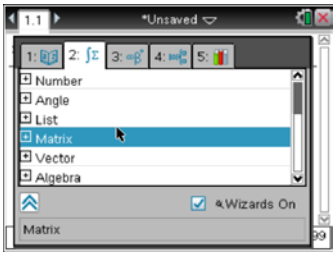


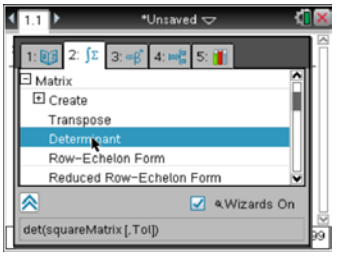
Some commands are difficult to remember how to use. Open the **Catalog** and locate the **polyRoots** command. Notice the syntax for the command at the bottom of the screen. Check the **Wizards On** box and click the chevron to see expanded syntax.



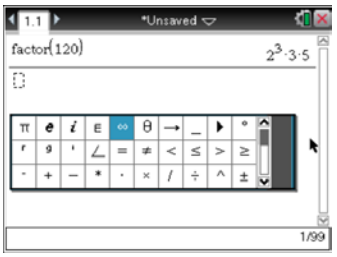


Press 2 or click the second tab to access the commands organized by topic. This part of the **Catalog** is useful if you know the general topic of a command but forget what it is called. Click on the topic to expand and see which commands are available.

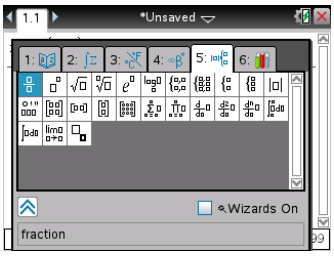


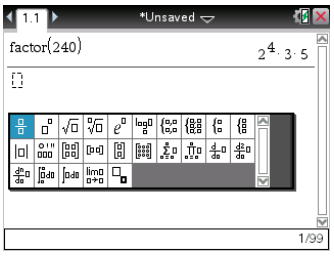


Press 3 or click the third tab to access the **Symbol** palette. You can also access the **Symbol** palette by pressing ctrl 📖 on the keypad. There are 543 symbols. You may notice that using the catalog to access the symbols allows you to see more symbols at one time.



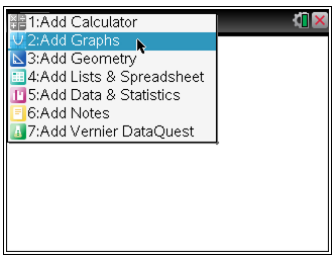
Press 4 or click the fourth tab to access the Math templates. You can also access the Math templates by pressing [|{]. The advantage of using the **Catalog** is that the template name appears near the bottom of the screen.

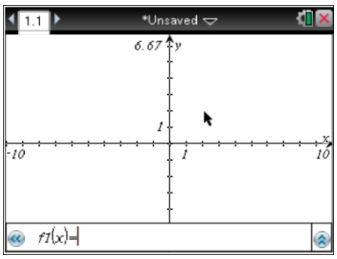




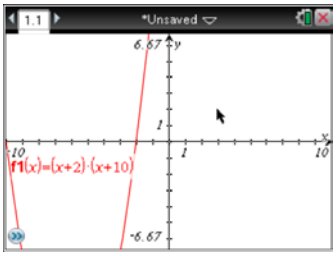
Adjusting the Window

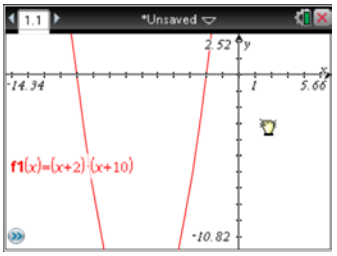
Insert a Graphs page:
Press ctrl I and choose **Add Graphs**.



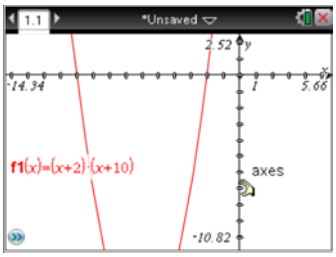


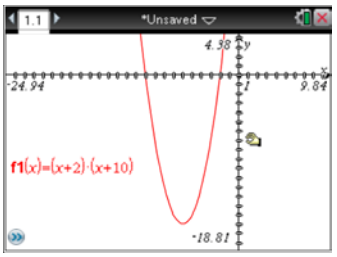
Graph the function $f1(x) = x - 2 \cdot (x + 10)$. Notice that you cannot see the whole parabola. Place your cursor in an open spot and grab (ctrl) the screen.
Method 1: Use the Touchpad to move the entire coordinate plane.



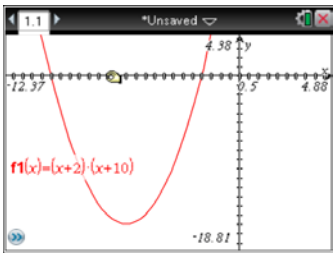


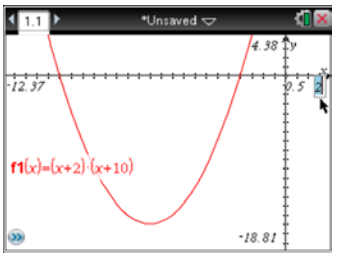
Method 2: Move your cursor over the axis until the word **axes** appears. Grab the axis (ctrl) and use your Touchpad to zoom out by dragging your hand towards the origin.



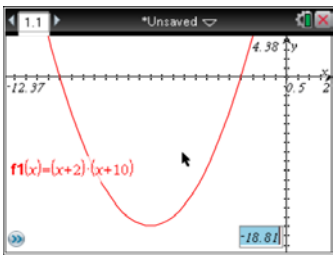


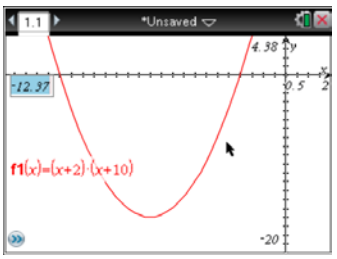
You can change the scale on only one axis by holding down the ⇧shift key as you drag the axis.
Method 3: Double-click on the end values and change them. When you press enter the changes will be reflected in the graphing window.



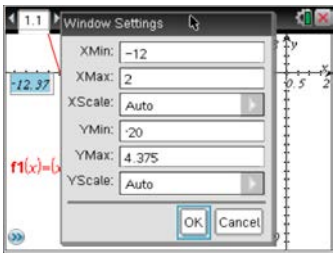


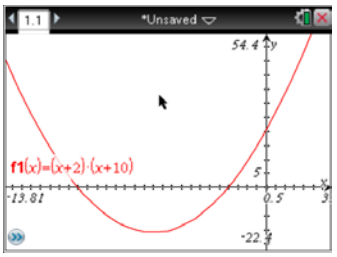
If you want to change more than one of the end values, then after you change one (but before you press enter), press tab to cycle to the next end value in a clockwise direction.





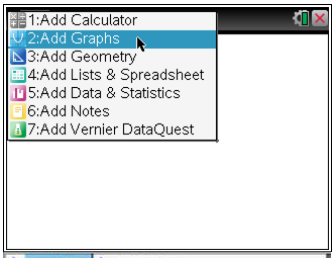
Method 4: Press **Menu > Window/Zoom > Window Settings** and adjust as desired.
Method 5: Use a **Zoom** feature. Press **Menu > Window/Zoom > Zoom Fit**.

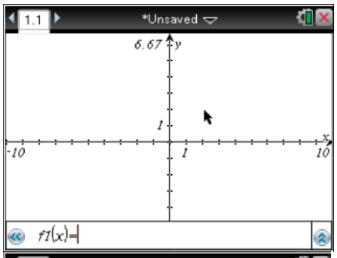




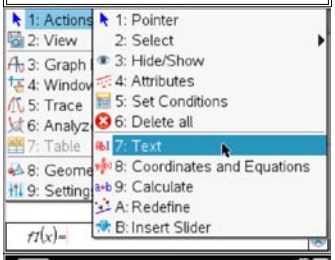
Graphing *f*(*y*) Equations

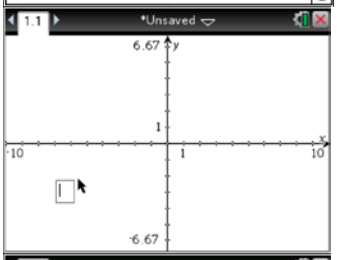
Insert a Graphs page:
Press ctrl I and choose **Add Graphs**.



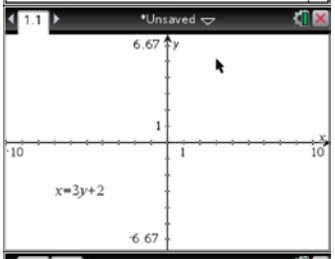


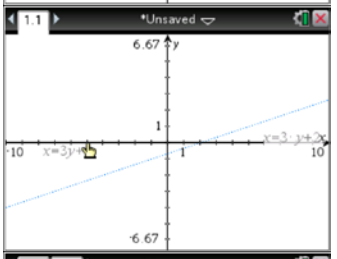
To insert a Text box, press **Menu > Actions >Text** and click in an open space. Alternatively, right-click (ctrl menu) in an open space and choose **Text**.





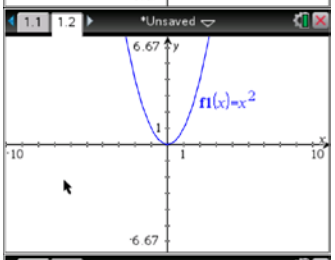
Type an *f*(*y*) equation in the text box $x = 3y + 2$ and press enter.

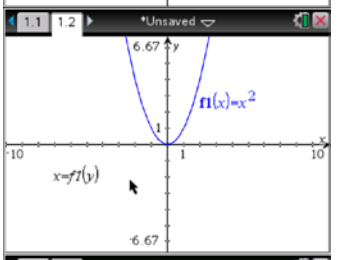




Grab (ctrl) and drag the text box to the x-axis to graph the *f*(y) equation. Drop the Text box on the *x*-axis to graph.

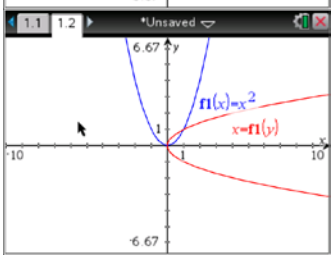
Press ctrl I and choose **Add Graphs** to add a new Graphs page. Graph the function $f1(x) = x^2$.
Insert a text box in an open space (ctrl menu and choose Text). Then type $x = f1(y)$.

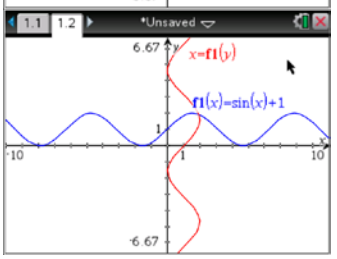




Grab (ctrl) and drag the Text box to the *x*-axis. Drop the Text box on the *x*-axis to graph the inverse relation of *f*1.

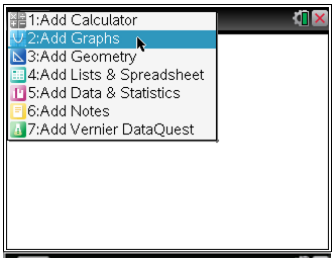
Double-click the *f*1(*x*) function label and edit it. Notice that the inverse relation updates automatically.

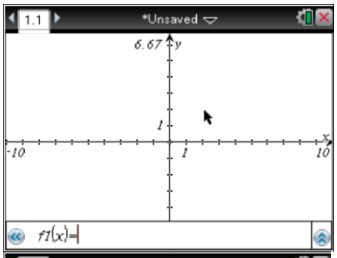




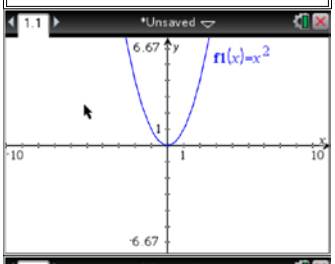
Calculating Points of Intersection

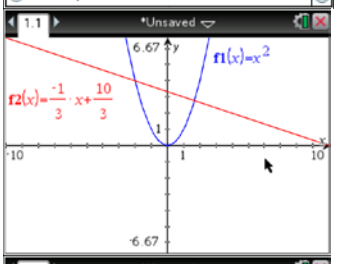
Insert a Graphs page:
Press ctrl I and choose **Add Graphs**.



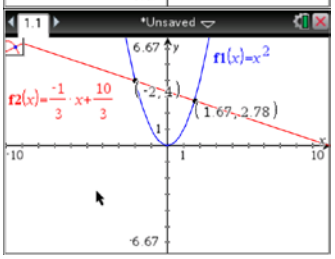


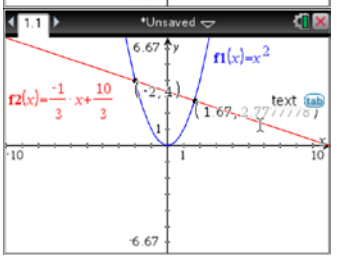
Graph the function $f1(x) = x^2$.
Press ctrl G to open the entry line and graph the function $f2(x) = \frac{-1}{3}x + \frac{10}{3}$.



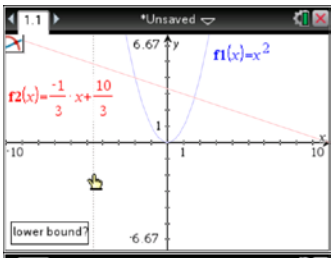


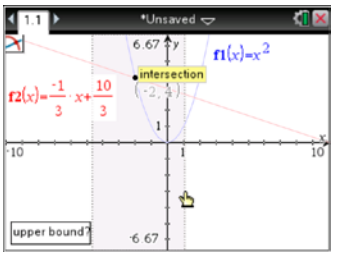
Method 1: Press **Menu > Geometry > Points & Lines > Intersection Points**. Click on both graphs to calculate the points of intersection.
Press esc. Hover over the *y*-coordinate of the point and press + or − repeatedly to see more (or fewer) decimal places.





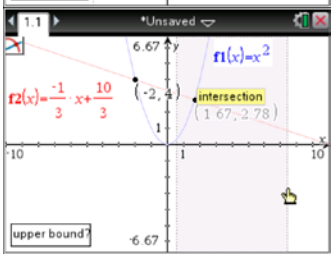
Note: If you find the intersection point with an axis, the coordinates do not automatically show. Right-click (ctrl menu) on the point and choose **Coordinates and Equations** to label the ordered pair.
Method 2: Press ctrl esc a few times to undo the intersection points you just found. Press **Menu > Analyze Graph > Intersection**. Click to the left of an intersection point to establish the lower bound. Then use the Touchpad to move to the right; click to establish the upper bound.





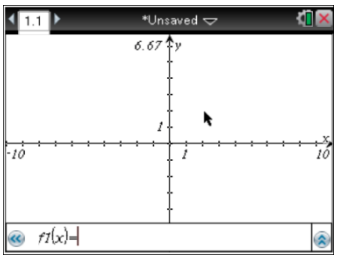
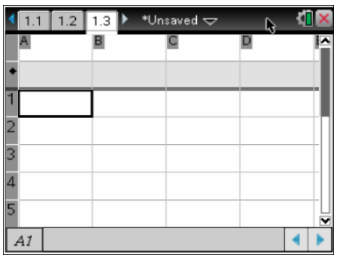
Only one intersection point can be found at a time using the **Analyze Graph** menu.

Repeat and choose different lower and upper bounds to find the other intersection point.

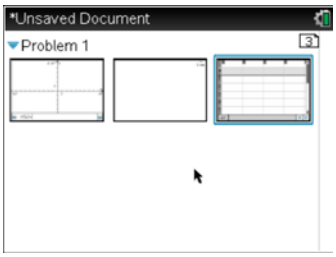
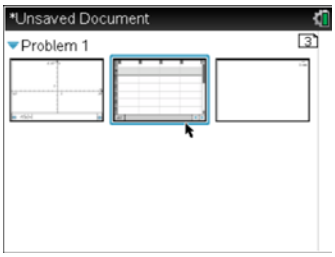


Managing Pages in a Document

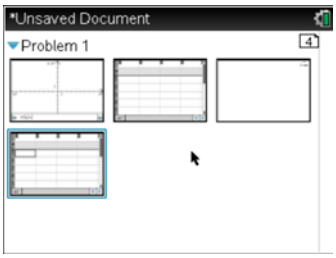
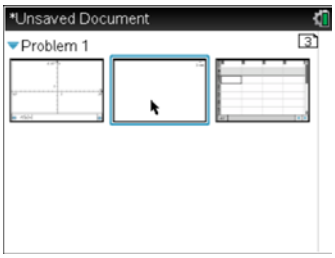
Insert a Graphs page:
Press ctrl I and choose **Add Graphs**.
Insert a Geometry page:
Press ctrl I and choose **Add Geometry**.
Insert a Lists & Spreadsheet page:
Press ctrl I and choose **Add Lists & Spreadsheet**.

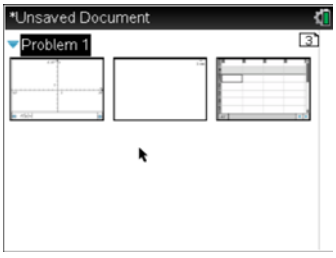
Access the **Page Sorter** view by pressing ctrl ▲. This is a thumbnail view of the screens. You can change the order of the screens by grabbing a page (ctrl) and using your Touchpad to move it.

You can copy (ctrl C), cut (ctrl X), paste (ctrl V), and even delete (del) pages in this view. Click on the thumbnail and use the shortcut keystrokes to edit as desired.

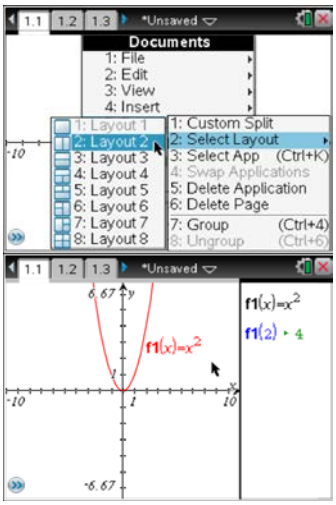
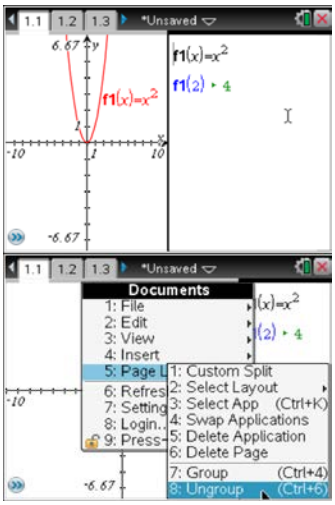



To copy and paste a whole problem, click on the Problem 1 label, press ctrl C to copy, and then ctrl V to paste.
Delete an entire problem by clicking on the Problem label and pressing del.



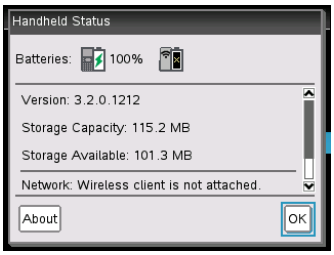

Click on a Graphs page thumbnail and enter **f1(*x*) = x^2**. To split the screen, press doc **> Page Layout > Select Layout > Layout 2**. Then, move your cursor to the screen on the right, press **Menu > Add Notes**.

Press doc **> Page Layout > Custom Split**. Use your Touchpad to adjust the size of the split screen. Try using the **Ungroup** tool to separate the split screen into two separate pages. Press doc **> Page Layout > Ungroup** (alternatively, press ctrl 6).

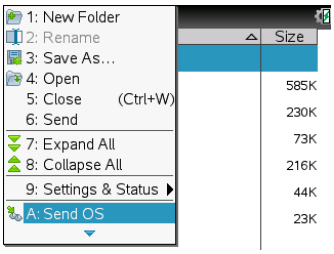



Updating the Operating System

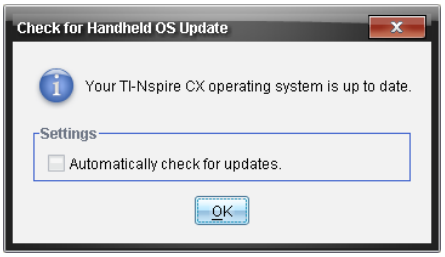
Check the operating system (OS) by pressing **Menu > Settings > Status**. In addition to the OS, notice the battery status, available memory and information regarding TI-Nspire™ Navigator™ status.



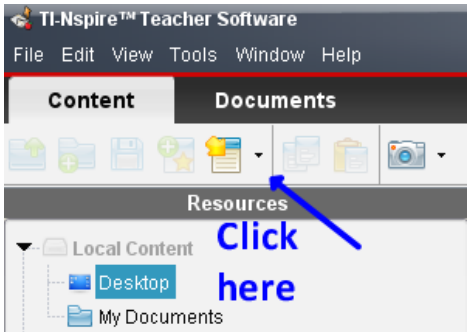
You can transfer an OS from one handheld to another. On the sending handheld, press [on] **> My Documents**. Then press **Menu > Send OS**.



You can set your TI-Nspire™ Teacher Software to automatically check for handheld updates. On the software, click **Help** and choose **Check for Handheld OS Update**. If desired, click the box next to **Automatically check for updates** to have the handheld automatically check for updates to the OS when it is connected to the computer.



You can also use your TI-Nspire Teacher Software to send out the OS to more than one handheld at once. Under the **Content** tab, Click the **Send selected to** icon and choose **Send to Selected Handhelds**. Locate the OS on your computer and send it.
To download the latest handheld OS, go to education.ti.com.



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TI-Nspire™ Keypad Shortcuts

TI PROFESSIONAL DEVELOPMENT

Activity Overview

The following keypad shortcuts can be used to perform common functions on the TI-Nspire™ CX family of handhelds. Many shortcuts can also be uysed in the TI-Nspire™ and TI-Nspire™ CAS Teacher Software, as well as by selecting options from various menus and submenus.

Getting Help	
Open Hints	ctrl trig
Editing Text	
Cut	ctrl X
Copy	ctrl C
Paste	ctrl V
Undo	ctrl Z or ctrl esc
Redo	ctrl Y or shift esc
Toggle approximate and exact results	ctrl enter
Change key to include appropriate accent	
Inserting Characters and Symbols in a Document	
Display character/symbol palette	ctrl
Underscore	ctrl
Display math template palette	
Backslash	shift ÷
Manual data capture point	ctrl .
Clear	ctrl del
Caps lock	ctrl shift
Store	ctrl var
Square brackets	ctrl (
Curly brackets	ctrl)
Display Trig symbol palette	trig
Equals symbol	=
Display pi symbols palette (π, /, θ, and so on)	
Display equality/inequality palette (>, <, ≠, ≥, ≤, |)	ctrl =
Display marks and letter symbols palette (? ! $ ‘ “ : ; _ \)	?!
Square root	ctrl x^2
log	ctrl 10^x
ln	ctrl e^x
ans	ctrl (−)

TI-Nspire™ Keypad Shortcuts

TI PROFESSIONAL DEVELOPMENT

Managing Documents	
Open document menu	doc ▾
Open document	ctrl O
Close document	ctrl W
Create new document	ctrl N
Insert new page	ctrl I
Select application	ctrl K
Save current document	ctrl S or ctrl

Navigation	
Top of page	ctrl 7
End of page	ctrl 1
Page up	ctrl 9
Page down	ctrl 3
Up a level in the hierarchy	ctrl ▲
Down a level in the hierarchy	ctrl ▼
Context menu for selection	menu
Extends selection in direction of arrow	shift any arrow

Navigating in Documents	
Displays previous page	ctrl ◀
Displays next page	ctrl ▶
Displays Page Sorter	ctrl ▲
Exits Page Sorter	ctrl ▼
Switch between applications on a split page	ctrl tab
Moves focus backward within a page	shift tab

Wizards and Templates	
Add a column to a matrix after the current column	shift ↵
Add a row to a matrix after the current row	↵
Integration template	shift +
Derivative template	shift −
Math template palette	or ctrl
Fraction template	ctrl ÷

TI-Nspire™ Keypad Shortcuts

TI PROFESSIONAL DEVELOPMENT

Modifying the Display

Increase contrast	ctrl +
Decrease contrast	ctrl −
Power off	ctrl on

Using Application-Specific Shortcuts

Select all in Notes or Program Editor	ctrl A
Check syntax and store (in Program Editor)	ctrl B
Find (in Program Editor)	ctrl F
Hide/Show Entry Line (in Graphs or Geometry)	ctrl G
Go To (in Lists & Spreadsheet, Program Editor)	
Find and Replace (in Program Editor)	ctrl H
Insert Math Box (in Notes)	ctrl M
Open the Scratchpad	
Recalculate (in Lists & Spreadsheet)	ctrl R
Add Function Table (in Lists & Spreadsheet, Graphs, and Geometry)	ctrl T
Group/ungroup	ctrl 4 / ctrl 6

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Checking and Updating the Operating System

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will learn how to check the operating system (OS) on a TI-Nspire™ handheld and update it using the TI-Nspire™ Teacher Software.

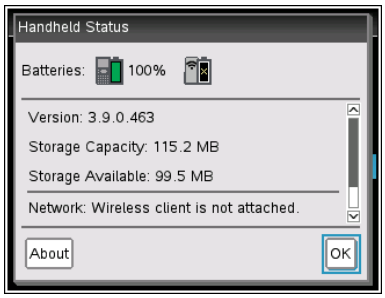
Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software and standard-A to mini-B USB cable

Viewing Handheld Status

The Handheld Status screen displays the battery status, (OS) version, available space, the network (if any), and your student login name and whether you are logged in.

To view the Handheld Status, press on and select **Settings** > **Status**. The Handheld Status dialog box opens.



Note: The About screen displays the handheld type and product ID. To view the About screen from the Handheld Status screen, click **About**. To return to the home screen, press enter.

Updating the Handheld OS

You can update the OS on your TI-Nspire™ handheld using the TI-Nspire™ Teacher Software or by transferring the OS from one handheld to another. OS upgrades do not delete user documents. If there is not enough room on the receiving handheld for the upgrade, the sending device is notified. The only time documents can be affected by an OS installation is if the receiving handheld has a corrupted OS. It is a good practice to back up important documents and folders before installing an updated OS.

Important OS Download Information

In the TI-Nspire™ family of handhelds, different handheld types require different operating systems:

- The OS for the TI-Nspire™ CX handheld has the file extension *.tco*.
- The OS for the TI-Nspire™ CX CAS has the file extension *.tcc*.
- The OS for the TI-Nspire™ with Touchpad or Clickpad has the file extension *.tno*.
- The OS for the TI-Nspire™ CAS with Touchpad or Clickpad has the file extension *.tnc*.

Always make sure the TI-Nspire CX handheld is fully charged before beginning an OS download (or, if using the TI-Nspire with Touchpad or Clickpad, install new batteries).

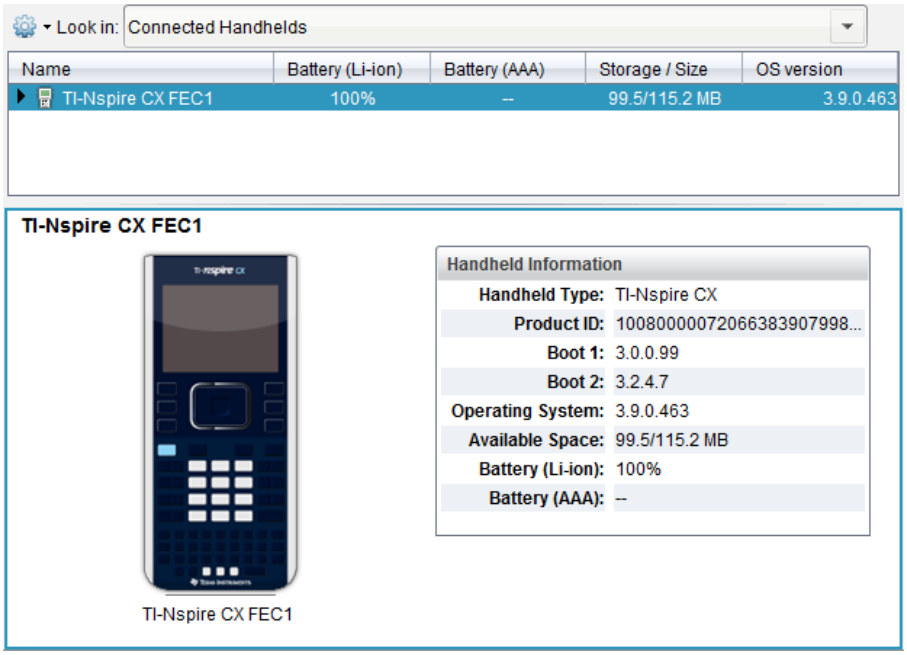
Finding Operating System Upgrades

Your TI-Nspire™ Teacher Software has convenient links to a number of useful Texas Instruments web sites, including those with handheld OS updates. You will need an Internet connection and the USB connection cable to download and install the updates.

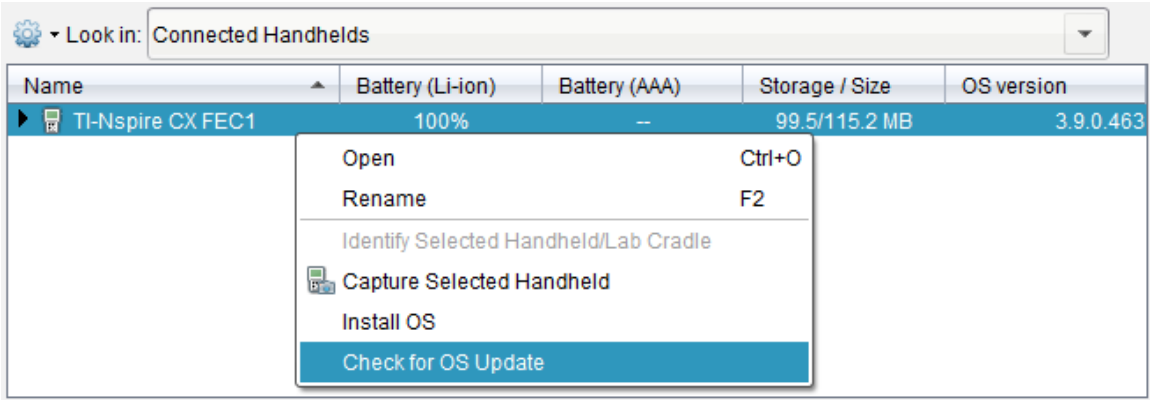
Using TI-Nspire Teacher Software to Update the Handheld OS

Open the TI-Nspire Teacher Software and connect a TI-Nspire handheld to the computer using the USB connection cable. Go to the Document Workspace, select the Content Explorer tab, and click **TI-Nspire™ Connected Handhelds**. Multiple handhelds can be connected to the computer using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected to the computer, then multiple handhelds appear in the list of Connected Handhelds.

The connected handheld appears in the Content Window. Click on the name of the handheld to display battery, storage, and OS information. More detailed information appears in the Handheld Information window.



To see if a new OS is available, right-click on the row that includes the handheld's name. Select **Check for OS Update**. If there is a newer version of the OS available, follow the directions to install it. A window will inform you that any unsaved data will be lost. If you want to continue, select **Yes**.



Transferring Documents Between Handhelds

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will learn how to transfer a document from one TI-Nspire™ CX handheld to another.

Materials

- Two TI-Nspire CX handhelds
- Unit-to-unit connection cable (Mini-A to Mini-B USB)

Transferring a Document or a Folder

Documents can be transferred between two TI-Nspire CX handhelds by connecting them with the unit-to-unit mini USB cable. The USB A port is located at the top of the handheld on the right side.

Step 1:

Firmly insert the ends of the mini USB unit-to-unit cable into the USB A ports of the handhelds. The handhelds will automatically turn on when the cable is plugged in.

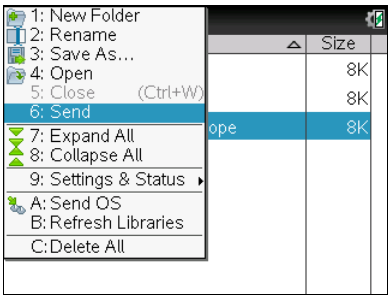
Step 2:

Open **My Documents** on the sending handheld.

Step 3:

Press the ▲ and ▼ keys to highlight the document or folder to send.

Step 4:



Press menu and select **Send**. No action is required by the user of the receiving TI-Nspire CX handheld. Once the transfer begins, a progress bar displays the status of the transfer. When the transfer is complete, a message displays on the receiving handheld. If the document was renamed on the receiving handheld, the new document name appears.

Note: When sending a folder from one handheld to another, the file structure in the sending folder is retained. If the folder does not exist on the receiving handheld, it will be created. If the folder does exist, files will be copied into it, with appended names added to any duplicate files.

Note: To cancel a transmission in progress, select **Cancel** in the dialog box of the sending handheld. To cancel a transfer from the receiving handheld, press esc. The receiving handheld, however, cannot cancel a transfer of folders. If an error message appears, press esc or enter to clear it.

Guidelines for Transferring Documents or Folders

The guidelines for sending an individual document also apply to documents within folders that are sent.

- If you send a document with the same name as an existing document on the receiving TI-Nspire CX handheld, the system renames the sent document by appending a number to the name. For example, if you send a document named *Mydata* to another TI-Nspire handheld that already contains a document named *Mydata*, the document you send will be renamed *Mydata(2)*. Both the sending and receiving units display a message that shows the new name.
- There is a 255-character maximum length for a document name, including the entire path. If a transmitted document has the same name as an existing document on the receiving handheld and the document names contain 255 characters, then the name of the transmitted document will be truncated to allow the software to follow the renaming scheme described in the previous bullet.
- All variables associated with the document being transmitted are transferred with the document.
- Transmissions will time out after 30 seconds.

Transferring Documents Using the TI-Nspire™ Teacher Software

TI PROFESSIONAL DEVELOPMENT

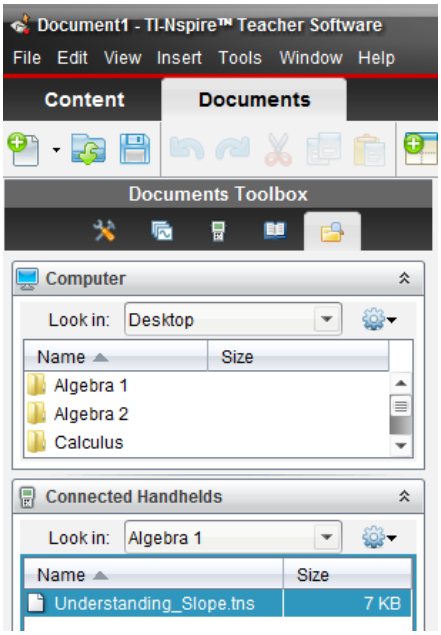
Activity Overview

In this activity, you will use the Documents and Content Workspaces of the TI-Nspire™ Teacher Software to transfer TI-Nspire™ documents between the computer and the handheld.

Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software
- TI-Nspire™ handheld and standard-A to mini-B USB cable

Transferring Documents in the Documents Workspace



Step 1:

Open the Teacher Software. Go to the Documents Workspace by clicking the **Documents** tab.

Step 2:

Connect a TI-Nspire™ handheld to the computer using the USB connection cable. Multiple handhelds can be connected using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected, then multiple handhelds appear in the Connected Handhelds panel.

Step 3:

Documents can be transferred between the computer and connected handhelds using the Content Explorer in the Documents Toolbox. Open the Content Explorer by clicking the **Content Explorer** tab.

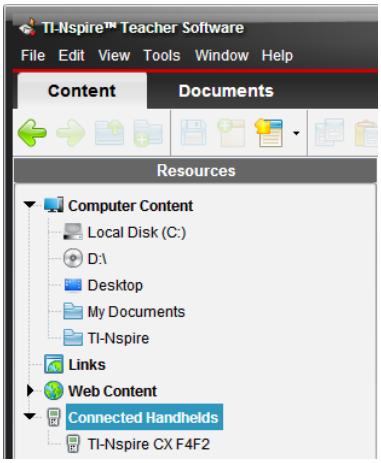
Step 4:

To transfer a TI-Nspire document from the computer to the handheld, locate the document in the Computer panel. Click, drag, and drop it into the handheld in the Connected Handhelds panel.

Step 5:

To transfer a TI-Nspire™ document from the connected handheld to the computer, locate the document in the Connected Handhelds panel. Click, drag, and drop it into the desired folder in the Computer panel.

Transferring Documents in the Content Workspace

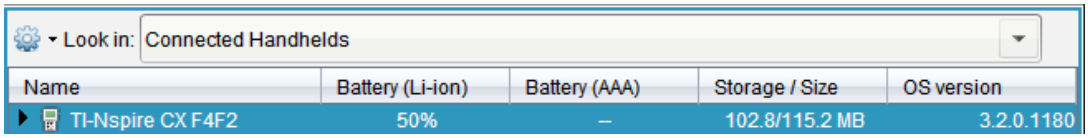


Step 6:

Go to the Content Workspace by clicking the **Content** tab. In the Resources panel, select **Connected Handhelds**.

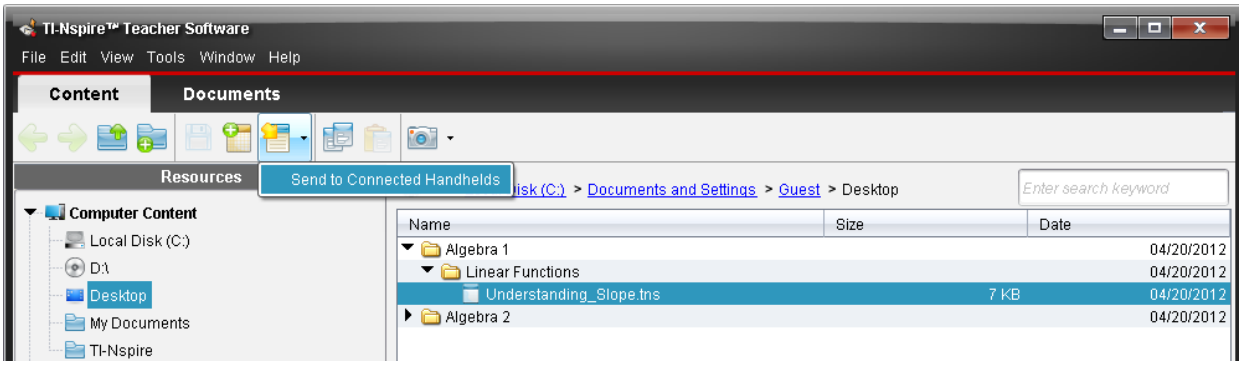
Step 7:

The connected handheld appears in the Content window, along with battery, storage, and OS information. To view the documents on a connected handheld, click the name of the handheld.



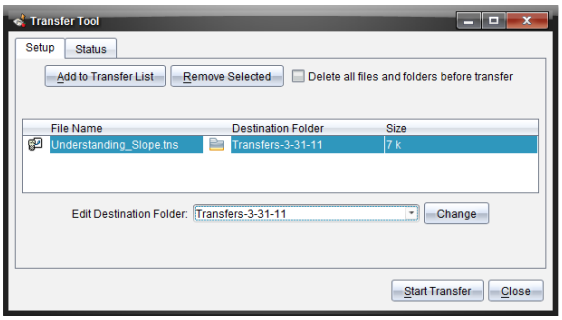
Step 8:

Locate a TI-Nspire™ document on your computer by browsing Computer Content in the Resources panel. Send the document by dragging and dropping it to the connected handheld. The document can also be sent by right-clicking it and selecting  **Send to Connected Handhelds**.



Step 9:

The Transfer Tool window appears with the current document. Documents can be added to or removed from the transfer list, and the destination folder on the handheld(s) can be edited or changed. To send the document to the handheld(s), click **Start Transfer**. Once the Status tab indicates that the transfer is complete, click **Stop Transfer**.



The Press-to-Test Feature

TI PROFESSIONAL DEVELOPMENT

Activity Overview

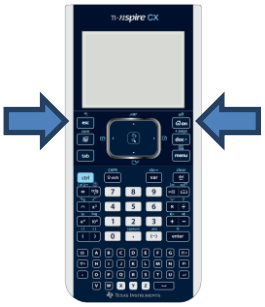
The Press-to-Test feature enables you to quickly prepare student handhelds for exams by temporarily disabling folders, documents, and select features and commands. Steps 1-7 in this activity enables Press-to-Test. To disable Press-to-Test, you will need to follow Steps 8-9 using either an additional TI-Nspire handheld or a computer with the TI-Nspire Teacher Software.

Materials

- TI-Nspire™ handheld-to-handheld or handheld-to-computer USB connection cable

Step 1:

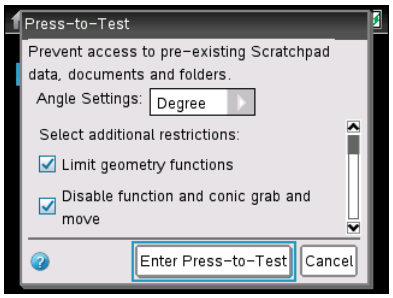
To enable Press-to-Test on the TI-Nspire™ with Touchpad and TI-Nspire CX™, first ensure that the handheld is turned off. Press and hold esc and on until the Press-to-Test screen appears.



Note: To enable Press-to-Test on TI-Nspire™ with Clickpad, press and hold esc, ⌂, and off on.

Step 2:

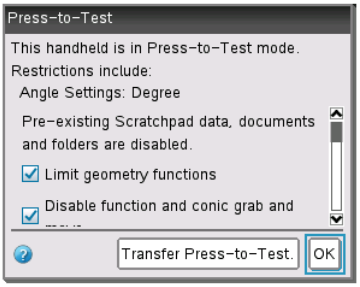
By default, Press-to-Test disables pre-existing Scratchpad data, documents, and folders as well as many other functionalities of the handheld. The angle settings can be changed by pressing ▶, selecting the appropriate setting, and pressing ▶ or enter.



By default, all of the commands and features listed are disabled. To enable a feature or command, uncheck its box. Keep all boxes checked, and enter Press-to-Test by clicking **Enter Press-to-Test**.

Step 3:

Once the handheld is in Press-to-Test mode, the handheld reboots. A dialog box confirms that the handheld is in Press-to-Test mode and the restrictions are listed. Click OK.



Step 4:

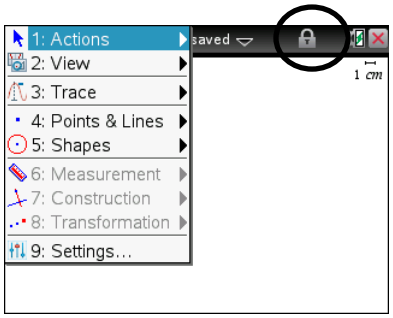
When in Press-to-Test mode, the LED at the top of the handheld begins blinking. Green indicates that all restrictions are selected (default), while yellow indicates that one or more restrictions are unselected. During the initial reboot, the LED alternates between red and, depending on the restrictions, either green or yellow.

The Press-to-Test Feature

TI PROFESSIONAL DEVELOPMENT

Step 5:

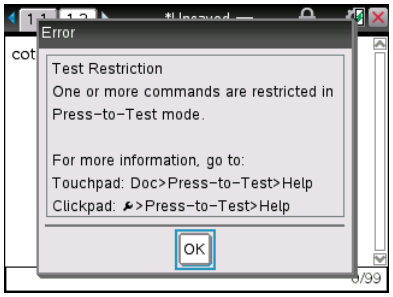
Create a new document, add a Geometry page, and press menu. Since geometry functions are limited, observe that the **Measurement**, **Construction**, and **Transformation** menus are not accessible.



Note: The lock icon at the top of the screen indicates that the handheld is in Press-to-Test mode.

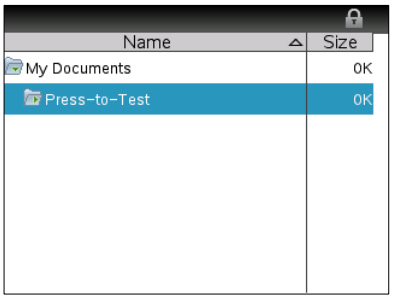
Step 6:

Add a Calculator application by selecting doc **> Insert > Calculator**. Type **cot(π/2)** and press enter. Since trigonometric functions are limited, an error message appears. The dialog box tells students how to access additional information about the restrictions. Click OK.



Step 7:

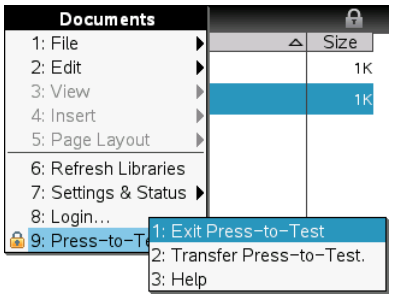
Select on **> My Documents.** While in Press-to-Test mode, a Press-to-Test folder appears in My Documents. All other folders and documents present on the handheld before Press-to-Test mode was entered are inaccessible.



Step 8:

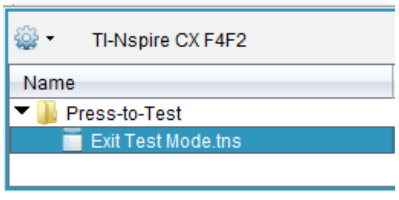
To exit Press-to-Test mode, connect two handhelds using the handheld-to-handheld USB connection cable. Then select doc **> Press-to-Test > Exit Press-to-Test**. The Exit Press-to-Test option appears regardless of whether the other handheld is in Press-to-Test mode.

Press-to-Test can also be exited with the TI-Nspire™ Navigator™ Teacher Software. Once a class has been started, students can select doc **> Press-to-Test > Exit Press-to-Test**.



Step 9:

Press-to-Test can also be exited with TI-Nspire Teacher Software or TI-Nspire Navigator Teacher Software by creating a document named ***Exit Test Mode.tns***, and transferring it to connected handhelds.



Note: The name of the TI-Nspire document must be spelled exactly as it is above.

Go to the Tools menu and select **Transfer Tool**. Click **Add to Transfer List** and select *Exit Test Mode.tns*. In the Edit Destination Folder, enter the name of the folder Press-to-Test, and click **Change**. Then, click **Start Transfer.**

The Common Core Mathematical Practices

TI PROFESSIONAL DEVELOPMENT

The eight Common Core Mathematical Practices that students should understand and enact in doing and thinking about mathematics are:

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning

In particular:

1. Make sense of problems and persevere in solving them

- consider analogous problems, special cases and simpler forms
- transform algebraic expressions or change the viewing window to obtain information needed
- use concrete objects or pictures to help solve a problem
- explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends
- make conjectures about the form and meaning of the solution and plan a solution path rather than jumping into a solution
- check answers to problems using a different method
- monitor and evaluate progress and change course if necessary
- understand and compare different approaches

2. Reason abstractly and quantitatively

- represent a given situation symbolically and manipulate the representing symbols
- stop and think about what the symbols represent in the context of a given situation
- reason with quantities and about relations among quantities
- consider the units involved
- attend to the meaning of quantities, not just how to compute them
- know and flexibly using different properties of operations and objects

3. Construct viable arguments and critique the reasoning of others

- make conjectures and build a logical progression of ideas
- use stated assumptions, definitions and previously established results in constructing arguments
- determine domains to which an argument applies
- analyze situations by breaking them into cases
- recognize and use counterexamples
- compare the effectiveness of two plausible arguments
- distinguish correct reasoning from that which is flawed and explain any flaws
- justify conclusions and communicate them to others

4. Model with mathematics

- write an equation to describe a situation
- apply mathematics to solve problems arising in everyday life, society, and the workplace
- identify important quantities in a practical situation and map their relationships using diagrams, two-way tables, graphs, flowcharts and formulas
- make assumptions and approximations to simplify a complicated situation
- interpret mathematical results in the context of the situation and reflect on whether the results make sense, improving the model as necessary

5. Use appropriate tools strategically

- make sound decisions about using tools, recognizing both the insight to be gained and their limitations
- use technology to visualize the results of varying assumptions, explore consequences, and compare predictions with data
- use technological tools to explore and deepen understanding of concepts
- identify relevant external mathematical resources and use them to pose or solve problems
- analyze graphs, functions and solutions generated by technology
- detect possible errors by using estimation and other mathematical knowledge

6. Attend to precision

- communicate precisely to others
- use clear definitions in discussion and in reasoning
- state the meaning of symbols used, specifying units of measure, and labeling axes
- calculate accurately and efficiently
- note the assumptions made
- express answers with an appropriate degree of precision

7. Look for and make use of structure

- look closely to discern a pattern or structure
- see complicated things (such as algebraic expressions or functions or a histogram) as single objects or being composed of several objects
- recognize and use the strategy of drawing auxiliary lines to support an argument

8. Look for regularity in repeated reasoning

- notice if calculations are repeated
- look for general methods and for shortcuts
- evaluate the reasonableness of intermediate results

Common Core State Standards for Mathematics. (2011).
www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

TI Technology Exam Acceptance

TI PROFESSIONAL DEVELOPMENT

TI-Nspire™ Technology

Approved for Tests	TI-Nspire™ CX TI-Nspire™ w/Touchpad	TI-Nspire™ CX CAS TI-Nspire™ CAS w/Touchpad
SAT*	●	●
AP*	●	●
PSAT/NMSQT*	●	●
ACT*	●	
International Baccalaureate	●	
Praxis™	●	●
Texas STAAR® Grade 8	●	
Texas STAAR® Algebra	●	

Graphing Technology

Approved for Tests	TI-84 Plus C Silver Edition TI-84 Plus Silver Edition TI-84 Plus, TI-83 Plus	TI-89 Titanium
SAT*	●	●
AP*	●	●
PSAT/NMSQT*	●	●
ACT*	●	
International Baccalaureate	●	
Praxis™	●	●
Texas STAAR® Grade 8	●	
Texas STAAR® Algebra	●	

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